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CONTRACT DOCUMENTS

October 31, 2025

TOWN OF
Truro
MASSACHUSETTS

New Department of Public Works Facility
17 Town Hall Road
Truro, MA 02666

W&S PROJECT No.: ENG24-1552

Volume III

Divisions 23 through 33

Issued for Design Development

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SECTION 23 00 01

HVAC FILED SUB-BID REQUIREMENTS (FILED SUB-BID)

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS:

- A. The Instructions to Bidders, Form of General Bid, Form for Sub-Bid, Agreement, Subcontract Form, General and Supplementary Conditions and complete specification are hereby made a part of these Specifications and Subcontractor shall consult them in detail for instructions.
- B. Work of this Section requires Filed Sub-Bids and is governed by the provisions of the Massachusetts General Laws (MGL), Public Bidding Law - Chapter 149, Sections 44A to 44J inclusive, as amended, and applicable Sections of the MGL, Public contract Law – Chapter 30.
- B. Specification requirements for the Filed Sub-Bid HVAC include the following listed **specification sections in their entirety:**
- C. The work to be completed by the Filed Subcontractor for the work of this Section is shown on the following listed Drawings, not just those pertaining particularly to this Sub-Trade, unless specifically called out otherwise, regardless of where among the **Drawings it appears:**
- D. Examine all Drawings and all other Sections of the project manual for requirements therein affecting Work of this Filed Subcontract.
- E. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure steady progress of all work under

Contract. This coordination requires familiarization with installation conditions shown on the following **Contract Drawings**:

- F. Sub-Bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the Owner at a time and place as stipulated in Sections 00100 Advertisement for Bids and 00200 Instructions to Bidders.

1. The following shall appear on the upper left-hand corner of the envelope:

NAME OF SUB-BIDDER: _____

SUB-BID FOR TRADE: HVAC

2. Each Sub-Bid submittal for work under this Section shall be on forms furnished by the Owner, as bound herein, accompanied by the required bid deposit in compliance with MGL Chapter 149 Section 44B in the amount of five (5) percent of the Filed Sub-Bid.

G. SUB-SUB BIDDERS:

The following items will be broken out on the Sub-Bid Form if the Sub-Bidder does not self-perform.

Building Management Systems	23 09 00
Testing, Adjusting, and Balancing	23 05 93
Sheet Metal	23 31 13
Insulation	23 07 13 & 23 07 19

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION

SECTION 23 00 50

BASIC HVAC REQUIREMENTS
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 – GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 SUMMARY:

- A. The work of Division 23 is governed by the General and Supplementary Conditions of the Contract, and Sections of Division 1 of the Project Manual.
- B. Perform work and provide materials and equipment as shown on Drawings and as specified or referenced in this Section of the Specifications. Completely coordinate work of this Section with work of other trades and provide complete and fully functional systems installation.
- C. Give notices, file plans, obtain permits and licenses, pay fees and backcharges, and obtain necessary approvals from authorities that have jurisdiction as required to perform work in accordance with all legal requirements and with the Contract Documents.
- D. Section Includes: The work of this Section includes the basic requirements common to the HVAC Sections of Division 23, including:
 - 1. Definitions,
 - 2. Organization of submittals,
 - 3. Proposed substitutions,
 - 4. Core drilling,
 - 5. Cutting and Patching,

6. Sleeves and penetrations,
 7. Coordination drawings,
 8. Valve tags,
 9. Equipment and piping identification,
 10. Record documents,
 11. Systems start-ups,
 12. Access Panels,
 13. Fire Watch,
 14. Scaffolding, hoisting, rigging and staging,
- E. Related Sections: Related work specified in other Sections includes, but is not necessarily limited to:
1. Section 01 33 13 – Submittals.
 2. Section 01 33 13.23 – Submittal of Operation and Maintenance Manuals.
 3. Section 01 73 29 – Cutting, Coring, and Patching: Openings in masonry, concrete, tile, and other parts of structure, except drilling for hangers, providing holes and openings in metal decks, and core drilling.
 4. Section 01 92 13 – Operations and Maintenance Manuals.
 5. Section 03 33 00 – Cast-in-Place Concrete: Housekeeping pads and inertia pads.
 6. Section 05 50 00 - Metal Fabrications: Structural supports necessary to distribute loading from equipment to roof, floor, walls or other building structural components.
 7. Section 07 62 00 - Sheet Metal Flashing and Trim.
 8. Section 07 84 43 – Fire Stopping: Caulking of pipe and duct penetrations through floor slabs and fire-rated or smoke partitions.

9. Section 07 92 00 – Joint Sealants: Sealing joints between plumbing fixtures and abutting surfaces.
10. Section 09 00 00 – Painting: Painting of exposed piping and equipment except as specified in this Section.
11. Division 22 – Plumbing
12. Division 23 – HVAC
13. Division 26 – Electrical.

1.3 REFERENCES:

- A. American National Standards Institute (ANSI)
 1. ANSI A13.1 - Scheme for the Identification of piping systems.
- B. ASTM International (ASTM)
 1. ASTM E119 - Test Methods for Fire Tests of Building Construction and Materials.
 2. ASTM E814 - Test Method for Fire Tests of Through-Penetration Fire Stops.
- C. Construction Specifications Institute. (CSI)
 1. Manual of Practice
- D. Underwriters Laboratories (UL)
 1. Fire Resistance Directory, Vol. I - Beams, Columns, Floors, Roofs, Walls, and Partitions.
 2. Fire Resistance Directory, Vol. II, Through Penetration Firestop Systems.
 3. ANSI/UL1479 - Fire Tests of Through Penetration Firestops.
- E. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).
 1. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.

- F. National Fire Protection Association
 - 1. No. 241-Safeguarding Construction, Alteration, and Demolition Operations.
- G. Code of Massachusetts Regulations (CMR)
 - 1. 248 CMR Massachusetts State Fuel Gas and Plumbing Code.
 - 2. 527 CMR Massachusetts Board of Fire Protection Regulations.
 - 3. 780 CMR Massachusetts State Building Code.
- H. International Code Council (ICC):
 - 1. International Building Code – IBC 2015.
 - 2. International Plumbing Code – IPC 2015.
 - 3. International Mechanical Code – IMC 2015.
 - 4. International Fire Prevention Code – IFPC 2015.
 - 5. International Energy Conservation Code – IECC 2018

1.4 DEFINITIONS:

- A. General: Words and terminology used throughout the HVAC Sections of Division 23 shall be understood in their common usage as defined in a common dictionary, and as further defined in the CSI Manual of Practice, the General and Supplemental Conditions of the Contract, Division 1 of the Project Manual, and the Sections of Division 23.
- B. Specification Content: The HVAC Specification Sections in Division 23 may use certain conventions regarding the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations or circumstances. These conventions are explained as follows:
 - 1. Abbreviated Language: Language used in Specifications and other Contract Documents maybe of the abbreviated style. Words and meanings shall be interpreted as appropriate. Words implied, but not stated shall be interpolated as the sense requires. Singular words will be interpreted as plural and plural words interpreted as singular where applicable as the context of the Contract Documents indicates.
 - 2. Streamlined Language: The Specifications generally use the imperative mood and streamlined language. Requirements expressed in the imperative mood shall be performed by the Contractor. At certain locations in the Text, subjective language is used for clarity to describe

responsibilities that must be fulfilled indirectly by the Contractor or by others when so noted.

- A. The words "shall be" are implied where a colon (:) is used within a sentence or phrase.
- C. Indicated: The term "indicated" refers to graphic representations, notes, or schedules on the Drawings, or other paragraphs or Schedules in the Specifications, and similar requirements in the Contract Documents. Terms such as "shown," "noted," "scheduled," and "specified" are used to help the reader locate the reference. Location is not limited.
- D. Directed: Terms such as "directed," "requested," "authorized," "selected," "approved," "required," and "permitted" mean directed by the Engineers, requested by the Architect, and similar phrases.
- E. Approved: When used in conjunction with the Engineer's action on the Contractor's submittals, applications, and requests, The term "approved," is limited to the Engineer's duties and responsibilities as stated in the Conditions of the Contract.
- F. Furnish: Furnish means purchase, delivery and storage at the Project Site for installation under other Sections or by the Owner.
- G. Install: Includes operations at the Project Site including the actual unpacking, preparation, assembly, erecting, placing, anchoring, supporting, connecting, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations required for a complete installation ready for the intended use.
- H. Provide: Provide means to furnish and install.
- I. Project Site: Project Site is the space available to the Contractor for performing construction activities, either exclusively or in conjunction, with others performing other work as part of the Project. The extent of the Project Site is shown on the Drawings and may or may not be identical with the description of the land on which the Project is to be built.
- J. Testing Agencies: A testing agency is an independent entity engaged to perform specific inspections or tests, either at the Project Site or elsewhere, and to report on and, if required, to interpret results of those inspections or tests.
- K. Product Data: Product data sheets include the manufacturers standard catalog information with illustrations, standard schedules, diagrams, performance charts, instructions, and brochures that illustrate physical appearance, size, weight, and other general characteristics of materials and equipment for some portion of the work.

- L. Shop Drawings: Shop drawings are detailed drawings, diagrams, illustrations, and schedules specifically prepared by the installing contractor or supplier to illustrate some portion of the work.
- M. Fabrication Drawings: The installation shop drawings required by the work of the various Sections of the Project Manual, such as sheet metal and sprinkler shop drawings, and normally prepared by the installing sub-contractor.
- N. Coordination Drawings: The coordinated installation shop drawings normally prepared by the installing sub-contractors indicating multiple building systems and interdisciplinary work on a single set of coordinated documents.
- O. Piping: Includes all necessary piping system components, including pipe, fittings, couplings, gaskets, flanges, unions, valves, strainers, hangers, supports, attachments, insulation, and identification.
- P. Substitutions: Substitutions include manufacturers not listed as acceptable within the specifications, or materials, products, systems, or equipment, which differ from the requirements of the Contract Documents.
- Q. Regulations: Regulations includes laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, as well as rules, conventions, and agreements within the construction industry that control performance of the Work.
- R. NRTL: Nationally Recognized Testing Laboratory such as Underwriters Laboratory, Inc. or Factory Mutual Research Corporation.
- S. Life Safety Systems: Life Safety Systems include all fire protection systems, devices, and equipment used to detect fire, activate alarms, suppress or control fire and smoke, or any combination thereof.

1.5 SUBMITTALS:

- A. General Requirements: Comply with pertinent Submittals, the Sections of Division 23 - HVAC, and the additional requirements of this Section.
- B. Materials List: Within 30 calendar days after the Contractor has received the Owner's Notice to proceed, submit a list of the proposed materials to be provided under the work of the HVAC Sections of Division 23.
- C. Organization of Submittals: Organize submittals into comprehensible packages with related product data sheets and shop drawings organized and identified by Specification Section and Article numbers and titles. Organize submittals into packages in order as specified in the Sections of Division 23. Identify submittal

pages to indicate the specific equipment or fixture type the data sheet applies to by Article number and title. Submittals, which are not properly bound and identified, may be returned without review.

1. Indicate appropriate model numbers in manufacturers' brochures and cross out non-applicable information.
 2. Copies of faxed pages are unacceptable.
 3. Submit shop drawings for particular systems complete, simultaneously, and organized by system.
- D. Submittal Cover Sheet: Provide a completed cover sheet with each submittal package indicating the information on the following sample page:

SUBMITTAL COVER SHEET		
PROJECT:		CONTRACTOR:
SECTION NO.:		ARTICLE NO.:
DESCRIPTION:		
CONTRACT DRAWING REFERENCE NO.:		
EQUIPMENT IDENTIFICATION TAG NUMBER:		
SUBMISSION (CIRCLE ONE): FIRST, SECOND, THIRD, FOURTH		
DATE:		
INFORMATION AND CHECKLIST	REPLY	COMMENTS
1. Contractor's Log #ID		
2. Name, address, and phone number of supplier.		
3. Are all specified or scheduled items included and exactly match scheduled/specified items?	Yes No	
4. Is this item a substitution?	Yes No	
5. Are deviations clearly identified?	Yes No	
6. Does equipment fit space shown on construction documents, coordination drawings, and actual field conditions?	Yes No	
7. Has support, erection, weights, and installation been coordinated with all trades?	Yes No	
8. Does the proposed installation void warranties or violate UL or code requirements?	Yes No	
9. Does this material/equipment add expense to any other trade or project costs?	Yes No	
10. Does equipment require interface with other trades? List sections and specifics requiring coordination?	Yes No	
11. Is control interface coordinated?	Yes No	
12. List electrical characteristics (V/Ph/A)		

- E. After approval of the proposed materials list, provide complete submittals as soon as possible and with adequate time for processing in order to not delay the project.
- F. Submit for review of all project specific electronic reproducible drawings one electronic copy in Portable Document Format (PDF). If submitting hard copies, submit for review eight sets of detailed Shop Drawings and Product Data. Submittals for review shall include complete Specifications, including type of materials, electrical characteristics, capacities, performance and power requirements to determine compliance with Contract Documents. All data submitted including wiring diagrams shall be complete for all equipment and shall apply only to this specific project. All extraneous material shall be deleted or marked out. Items to be supplied shall be specifically indicated using a method that will be visible after photocopying.
- G. Contractor's Review: Review, stamp and certify each submittal prior to submission to the Architect. The certification shall state that the data and details contained on each Shop Drawing, Product Data, layout drawing, catalog data and brochure has been reviewed and that it complies with the Contract Documents in all respects. Shop Drawings, layout drawings, catalog data and brochures will not be reviewed and will be returned unchecked unless they are certified and all items specifically identified.
- H. Multiple submissions: It is intended that Submittal data be complete and accurate at the first submission. If the Submittal is returned marked "Resubmit" only one additional submission will be permitted.
 - 1. If the second submission is not acceptable, or if the submittal is not made within the specified time frame, the right of substitution and selection will be lost. At that time, the specified item shall be provided at no additional cost.
- I. Required Review Time: A minimum period of ten working days, exclusive of transmittal time, will be required in the Engineer's office each time Shop Drawings, Product Data, layout drawings, catalog data and brochures are submitted or resubmitted for review. A minimum period of fifteen working days exclusive of transmittal time will be required for reviewing substitute materials or manufacturer. The required review time, including multiple submission, shall be considered when scheduling the work.
- J. Submit Shop Drawings and Product Data sheets in a timely manner sufficiently in advance to give ample time for reviewing, correcting, resubmitting and re-reviewing if necessary. No claim for delay will be granted for failure to comply with this requirement.

- K. Equipment shall be of proper size for its allotted space. Equipment may be disassembled as required, where it does not invalidate the manufacturer's warranty, so that it can be installed through available window door, or louver openings.
- L. Schedule of Shutdowns: After the project construction schedule is developed, submit the following information to the Owner for all required shutdowns of existing systems.
 - 1. Date of proposed shutdown.
 - 2. List of systems to be affected.
 - 3. List of areas affected by the shutdown.
 - 4. Description of work to be performed.
 - 5. Estimated length of the shutdown.
- M. Piping Systems Schedule: Prepare and submit a schedule of HVAC piping systems to indicate the piping material, joints, and fittings to be used with each system.
- N. Insulation Schedule: Prepare and submit a schedule to indicate insulation types and thicknesses to be used on each HVAC piping system.
- O. UL Through-Penetration Firestop System Schedule: Prepare and submit a schedule to indicate the UL-System number for through-penetration assemblies to be used with all mechanical systems. Coordinate with the work of the Penetrations and Fire Stopping Section in Division 7.
- P. Shop Drawings: Submit product data sheets and shop drawings as specified within the HVAC Sections of Division 23.
- Q. Record Drawings: Prepare record drawings in accordance with the provisions of Division 1 governing - Project Record Documents and the additional requirements of this Section.
- R. Operation and Maintenance Manuals: Prepare and submit copies of the Operation and Maintenance Manuals as specified in the appropriate Section of Division 1 governing - Contract Close-out the additional requirements of this Section.
- S. Training Seminar Confirmation: Prior to the final completion of the project, submit copies of the training seminar sign in sheets and a letter to the Owner containing the names of training seminar participants, including instructor's

names, the name of the firms represented and the dates of the instruction seminars.

- T. Engineer's Action: Except for items submitted solely for record purposes or information, the Engineer will review each submittal for general compliance with the Contract Documents, as defined in the General Conditions, and return the submittal with comments.
- U. Action Stamp: The Engineer will attach a Submittal Review sheet to each submittal package to indicate the status of the submission and the action taken, as follows:
 - 1. Furnish as Submitted: Submission is generally in compliance with the intent of the contract documents and fabrication may be undertaken.
 - 2. Furnish as Noted: Submission is generally in compliance with the contract documents and fabrication may be undertaken with the corrections noted.
 - 3. Revise and Resubmit: Submission is not in compliance with the contract documents and requires substantial corrections. Fabrication work may not be undertaken.
 - 4. Rejected: Submission is not in compliance with the contract documents. Resubmit as specified.
 - 5. Submit Specified Item: Second submission is not in compliance with the contract documents. Submit specified item without deviation.
 - 6. Reviewed for Comment Only: Engineer is not responsible for the approval of the submittal.

1.6 QUALITY ASSURANCE:

- A. Qualifications: Use adequate numbers of skilled, licensed workers who are thoroughly trained and experienced and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.
- B. Standard of Quality: The manufacturers names specified first or scheduled on the drawings are used for the design and to establish the standards of function, dimension, space requirements, appearance, and quality upon which the Contract is based. Acceptable manufacturers' names are listed to provide competitive bids with the specified or scheduled manufacturer.
 - 1. Acceptable Manufacturers: The inclusion of a manufacturer's name within the list of acceptable manufacturers does not necessarily mean that

the manufacturer's standard product is equal to the specified or scheduled product without some required modification. The submitted product shall be equal in terms of quality, durability, appearance, space requirements, weight, strength, and design to the product required by the Contract Documents.

- C. Contractor's Review: It is solely the Contractor's responsibility to verify that the products of acceptable manufacturers and proposed substitutes meet or exceed the performance of the specified or scheduled product. To be considered acceptable, products must comply with the following for the full possible performance range:

1. Horsepower: Equal or less.
2. Efficiency: Equal or greater.
3. Capacities: Equal or greater.
4. Space/Clearances: Equal or greater.
5. Storage and Recovery: Equal or greater.
6. Warranty: Equal or better.
7. Weight: Equal or less.
8. Noise: Equal or quieter.

- D. Substitutions: Substitutions include manufacturers not listed as acceptable within the specifications, or products, systems and methods, which differ from the specified systems.

1. Comply with the provisions of the Instructions to Bidders and pertinent sections in Division 1. Submit list of proposed substitutes for review and approval in compliance with the Instructions to Bidders, AIA Document A701.
2. By the submission of a proposed substitution, the Contractor represents that he has reviewed the proposed substitution and certifies that:
 - A. The proposed substitution does not affect dimensions shown on drawings.
 - B. Changes to the building design, including A/E design and review time at a rate of 2.6 x DPE, detailing and construction costs caused by the requested substitution will be included in the bid price with no additional cost to the Owner.
 - C. The proposed substitution will have no adverse affect on other trades, the construction schedule, or specified warranty requirements.
 - D. Maintenance and service parts are available locally.

- E. All costs associated with or caused by the use of the proposed substitute will be covered by the Contractor.

E. Codes and Regulations:

- 1. In addition to complying with the specified requirements, comply with pertinent regulations of governmental agencies and authorities that have jurisdiction.
- 2. In case of conflict between or among specified requirements and pertinent regulations, the more stringent requirement will govern.

F. Qualifications for Welding and Brazing Work:

- 1. Qualify welding processes and welding operators in accordance with AWS Standard Qualification Procedure."
- 2. Provide certification that welders to be employed in work have satisfactorily passed AWS qualification tests.
 - A. If recertification of welders is required, retesting will be Contractor's responsibility.

1.7 DELIVERY, STORAGE, AND HANDLING:

- A. Protection: Use all means necessary to protect materials of the Mechanical Sections before, during and after installation and to protect installed work and materials of all trades and Sections.
- B. Replacements: In the event of damage, immediately make all repairs and replacement necessary to the approval of the Engineer at no change in Contract Sum.

1.8 PROJECT CONDITIONS:

- A. Comply with Article 2 of the Instructions to Bidders, AIA Document A701, including the Appendix. Visit the site prior to submission of bids and examine existing conditions to be familiar with the related implications to the Work of the HVAC Sections.
 - 1. Questions regarding the Bidding Documents: Submit questions and requests for clarifications in compliance with the Instructions to Bidders.
- B. Contract Documents: The Contract Drawings are diagrammatic and do not show every fitting and component and shall be used in conjunction with the specified requirements to provide complete and fully functional systems for the intended

use. The drawings and specifications are complimentary, and the requirements indicated on both establish the requirements of the Contract.

1. The Contract Drawings indicate the general locations of equipment and distribution systems throughout the project. The actual installation locations shall be coordinated by the contractor on site based on actual field measurements performed by the contractor.
- C. Document Review: Review the complete set of Contract Documents and be familiar with the space requirements and work of other Sections. Thoroughly review building sections, architectural details, space availability phasing requirements and mechanical drawings for a complete understanding of the scope and coordination requirements of the HVAC Sections.
- D. Scheduled Equipment: Standard manufacturers model numbers scheduled on the drawings shall be modified as specified in the descriptive specification for the scheduled equipment. The drawings generally define quantities, and the specifications further define equipment quality and system components, which may not be included in the standard model number.
- E. Pipe sizing notations: Pipe sizing notations run along the pipe from the larger sizes to the smaller size. Sections of pipe, which are not specifically identified with a pipe size, are the continuation of the previous larger pipe size indication. Pipe sizes change only where indicated by a notation change.
- F. Existing Conditions: The existing conditions indicated on the contract drawings are taken primarily from existing record drawings provided by the Owner and do not necessarily indicate actual as-built conditions. Preparation work of the mechanical and electrical sections includes the verification of existing conditions before the start of related installation work.

1.9 WARRANTY:

- A. Upon completion of the Work and as a condition of its acceptance and final payment, deliver to the Architect five (5) copies of a written Warranty agreeing to replace the work of Division 23, which fails due to defective materials or workmanship within one year after Date of Substantial Completion as that date is determined in accordance with the General Conditions. All refrigeration compressors shall have the manufacturer's extended warranty for a total of five (5) years.
- B. Failure due to defective materials or workmanship is deemed to include, but is not to be limited to:
 1. Failures in operating component or components.

2. Leakage from piping system.
 3. Code violations.
- C. Obtain written equipment and material warranties offered in manufacturer's published data without exclusion or limitation, in Owner's name.
 - D. Replace material and equipment that require excessive service during warranty period as defined and as directed by Architect.
 - E. Warranty shall include 24-hour service of complete system during warranty period at no cost to Owner. Choice of service organization shall be subject to Owner's approval.
 - F. Include copy of warranty in the Operation and Maintenance Manuals.
 - G. At end of warranty period, transfer manufacturer's equipment and material warranties still in force to Owner.
 - H. This Article shall not be interpreted to limit Owner's rights under applicable codes and laws and under this Contract.

1.10 MANUALS AND INSTRUCTIONS:

- A. Comply with pertinent provisions of the appropriate Section in Division 1 regarding - Contract Closeout.
- B. Operation and Maintenance Manuals: Bind Manuals in commercial quality, 8-1/2 x 11 inch three-ring binders with hardback washable, plastic cover, and provide identified dividers with tabs. Indicate appropriate model numbers in manufacturers' brochures and cross out non-applicable information. Review the Manuals with the Owner's maintenance personnel and add additional maintenance data sheets and information as directed by the Owner's Representatives. Copies of faxed pages are unacceptable.
 1. Obtain at time of purchase of equipment, three copies of operation, lubrication and maintenance manuals for all items. Assemble literature in coordinated manuals with additional information describing combined operation of field-assembled units, including as-built wiring diagrams. Manual shall contain names and addresses of manufacturers and local representatives who stock or furnish repair parts for items or equipment.
 2. Provide directions for and sequences of operation for HVAC systems of Division 23. Sequence shall list valves, switches, and other devices used to start, stop and control systems.

3. Lubrication instructions detailing type of lubricant, amount, and intervals recommended by manufacturer for each item of equipment. Include additional instructions necessary for implementation of first-class lubrication program. Include approved summary of lubrication instructions in chart form, where appropriate.
- C. Furnish three (3) copies of manuals to Architect for approval and distribution to Owner. Deliver manuals no less than 30 days prior to acceptance of equipment to permit Owner's personnel to become familiar with equipment and operation prior to acceptance.
- D. Organization of Manuals: Divide manuals with identified tabs to match the mechanical and electrical specification sections numbers and titles. Separate product information within each section by the Article numbers and titles as listed in Part 2 of each specification section. Provide a clear see-through plastic holder on the edge of the binder with a typed card indicating the Project name, the Engineer's name, the Installer's name and the Volume number (e.g., Vol. No. 1 of 2).
- E. Manuals shall include the following materials and information for all specified materials and equipment:
1. Table of contents.
 2. Emergency instructions with 24-hour phone number to contact a responsible individual for each Section of Work.
 3. Subcontractor's warranties.
 4. Name and telephone number of local representative and supplier.
 5. Manufacturers' maintenance procedures.
 6. Exploded drawings and parts lists.
 7. Troubleshooting checklists with potential problems and possible causes.
 8. Schematic wiring diagrams.
 9. Record drawings.
 10. Equipment warranties and guaranties.
 11. Sequence of Operations and Systems Descriptions.
 12. Additional requirements specified in other sections.

- F. Maintenance Information: Systems which require preventive maintenance to maintain efficient operation shall be furnished with complete necessary maintenance information. Required routine maintenance actions, as specified by the manufacturer, shall be stated clearly and incorporated on a readily accessible label on the equipment. Such label may be limited to identifying, by title or publication number, the operation and maintenance manual for that particular model and type of product.
- G. Instruction Seminars: Perform systems instruction seminars and walk-through with the Owner's designated representatives after preparation, review and approval of the Operation and Maintenance manuals by the Architect and Owner.
 - 1. Record the names and firms represented of all training seminar participants, including all instructors and manufacturers representatives on a seminar sign in sheet.
 - 2. During the instruction period the Operation and Maintenance Manual shall be used and explained.
- H. As a minimum training sessions shall consist of the following:
 - 1. General project information and review shall be by the General Foreman or Superintendent of the Trade.
 - 2. Specific system and equipment training shall be by a Factory Trained Representative.
 - 3. Provide a complete review of the project and systems including, but not limited to, the following:
 - A. In a classroom environment mount the drawings on an easel or equivalent and review each Record Drawing (can use typical).
 - B. Note equipment layouts, locations and control points.
 - C. Review each system.
 - D. Review system design operation and philosophy.
 - E. Review alarms and necessary responses.
 - F. Review areas served by various equipment and systems.
 - G. Identify color codes used.

- H. Review features and special functions.
 - I. Review maintenance requirements.
 - J. Review operation and maintenance manuals.
 - K. Respond to questions. Record questions and answers.
4. After classroom training, walk the entire project, review each equipment room and typical locations. Explain equipment and proper operation.

1.11 RECORD DOCUMENTS:

- A. Prepare record documents for the work of Division 23 as specified in Division 1 for Project Record Documents. The record drawings shall accurately indicate all valve locations and shall clearly show the assigned valve tag number. Record drawings shall include:
 - 1. Piping and equipment location changes from the Contract Documents.
 - 2. Updated schedules to indicate the scheduled characteristics of the actual installed equipment.
 - 3. Equipment identification numbers coordinated with the Owner's Facility Management Program.
 - 4. Locations of seismic restraints.
- B. Record drawings include ductwork, sprinkler and fabrication drawings required for all other systems and coordination drawings prepared under the work of this contract. Provide polyester mylar reproducible drawings and electronic AutoCAD or Revit files of both the contract drawings and additional fabrication/coordination drawings that indicate mechanical and electrical systems. All electronic files shall be fully bound and submitted on CD format.

1.12 ELECTRONIC DRAWING FILES:

- A. Electronic drawing files of floor plans and schedules on AutoCAD, Revit, or DXF format will be made available by the Engineer for the Contractor's use to prepare fabrication, coordination or record drawings. After the Contractor requests the electronic files, a waiver will be provided for the Contractor to sign and return to Weston & Sampson Engineers, Inc. A service charge of one hundred dollars (\$100.00) per disc will be charged to cover the cost of the Engineer's time and materials. After Weston & Sampson Engineers, Inc. receives the signed waiver the electronic drawing files will be forwarded to the Contractor.

1.13 HVAC/ELECTRICAL SCOPE DELINIATIONS

- A. Unless otherwise called out in the plans and specifications, HVAC/Electrical coordination shall be:
1. Motors. Division 23 - HVAC shall provide motors for all HVAC equipment and shall be provided by the specific equipment manufacturer. All motors provided by Division 23 - HVAC shall conform to the requirements of Section 23 05 13 Common Motor Requirements for HVAC Equipment. Motors for Division 23 shall be Premium Efficiency.
 2. Motor Starters not located in a Motor Control Center (MCC). Division 23-HVAC shall provide motor starters for all HVAC equipment that is not controlled by a Motor Starter located in an MCC or by a VFD. Whenever possible Motor Starters shall be factory mounted and wired. For Motor Controllers that are remotely located, Division 26 shall wire the motor to the Motor Starter. All Motor Starters provided by Division 23 – HVAC shall conform to the requirements of Section 26 29 13 - Manual and Magnetic Motor Controllers
 3. Motor Starters and Variable Frequency Drives (VFDs) located in MCCs. Division 26 shall provide all Motor Starters and VFDs that are located in an MCC.
 4. Variable Frequency Drives (VFDs) not located in an MCC. Division 23-HVAC shall provide VFDs for motors as called out in the HVAC schedules. Whenever possible VFDs shall be factory mounted and wired. For motors that are remotely located, Division 26 shall wire the motor to the VFD. All VFDs provided by Division 23 – HVAC shall conform to the requirements of Section 26 29 23 - Variable Frequency Motor Controllers

PART 2 - PRODUCTS

2.1 PRESSURE VESSELS:

- A. Pressure vessels including provided under Division 23 shall be ASME rated construction.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Inspect site conditions before starting preparatory work and verify that actual conditions are known and acceptable before starting work. Be familiar with the work of other sections, separate contractors, and the Owner.
- B. Inspect areas where piping, conduit, ductwork, fixtures and equipment will be installed and verify adequate space is available for access, service and removal of equipment. Coordinate with the Work of other Sections.

3.2 PREPARATION:

- A. Perform coordination with the work of other Sections and prepare composite coordination drawings as specified in this Section before starting installation work of Division 23.

3.3 LIFE SAFETY SYSTEMS SHUTDOWNS:

- A. Maintain the existing Life Safety Systems in operation during construction and obtain impairment permits from the local Authorities Having Jurisdiction for all Life Safety Systems affected by the work of Division 23.
- B. Safeguarding Construction: Provide fire watch, portable extinguishers, and safety procedures in compliance with 527 CMR 39.00, 780 CMR 3305 and NFPA 241.

3.4 CORE DRILLING:

- A. Do not core new concrete structure without written approval from the Engineer.
- B. Perform all core drilling required for the proper installation of the work of Division 23. Locate all required openings and prior to coring coordinate the opening with the other Trades and obtain approval from the Engineer.
- C. Thoroughly investigate the existing conditions in the vicinity of the required opening prior to cutting. Take care so as not to disturb the existing building systems. Damage to existing conditions incurred during core drilling shall be corrected to the Owners satisfaction with no additional expense to the Owner.

3.5 CUTTING AND PATCHING:

- A. Cutting and patching shall be performed under other Sections. Locate all other than cored openings required for the installation of the mechanical piping systems. Coordinate the opening with the work of the other trades so as not to

interfere with the work of other Sections. Thoroughly investigate the existing conditions in the vicinity of the required openings as much as possible.

- B. Patching of the existing walls around openings shall be performed by the respective trade responsible for the finish material in which the opening is made.

3.6 GENERAL INSTALLATION REQUIREMENTS

- A. General: Coordinate with the work of other trades before starting installation. Install materials and equipment in accordance with the Manufacturers latest printed installation instructions and the product NRTL listing requirements.
 - 1. Install piping straight, plumb and form right angles on parallel lines with building walls. Locate groups of pipes parallel to each other. Provide sufficient spacing for insulation and valve access.
 - 2. Install systems as high as possible to maximize ceiling heights.
 - 3. Pipe shall be free from scale and dirt. Protect open ended pipe ends to prevent debris from entering. All piping shall be reamed free of burrs.
 - 4. Locate valves for easy access and operation. Install valve stems above the horizontal.
 - 5. Piping connections to coils and equipment shall be made with off-sets provided with isolation valves, unions or flanges arranged so that equipment can be serviced or removed without dismantling.
 - 6. Provide for expansion and contraction in all piping systems to prevent undue strains on piping or equipments. Provide double off-sets at risers to take up expansion.
 - 7. Install equipment with care to minimize damage to shop applied finishes. Replace or repair damaged components or finishes incurred during shipping and installation to the Owners satisfaction.
 - 8. Thoroughly clean items before installation. Cap pipe openings to exclude dirt until fixtures are installed and final connections have been made.
 - 9. Cut pipe accurately and work into place without springing or forcing, and properly clearing windows, doors, and other openings.
 - 10. Show no tool marks or threads on exposed plated, polished, or enameled connections from fixtures. Tape all finished surfaces to prevent damage during construction.

11. Make changes in directions with fittings, make changes in main sizes with eccentric reducing fittings. Install water supply and return piping with straight side of eccentric fittings at top of the pipe.
12. Install equipment and components to minimize noise and vibration transmission to the structure. Provide vibration isolators and flexible connectors for all vibrating equipment.
13. Provide sufficient swing joints, ball joints, expansion loops, and devices necessary for a flexible piping system.
14. Support piping independently at pumps, coils, tanks and similar locations, so that weight of piping will not be supported by the equipment.
15. Pipe the drains from pump glands, drip pans, relief valves, air vents and similar locations, to spill through an air gap into a floor drain.
16. Securely bolt all equipment, isolators, hangers, and similar items in place.
17. Provide complete dielectric isolation between ferrous and non-ferrous metals.
18. Do not install plastic piping systems when the ambient temperature is below 60 degrees F.
19. Provide Armstrong Armaflex 2000 white insulation on pipe hangers, duct hangers, duct flanges, the edge of ductwork, and to the sharp edges of mechanical systems when located below 6'-8" above the floor.
20. Insulating Clamps: Provide IPS Corp. Strap-Tite insulating clamps on uninsulated copper piping installed through metal stud perforations.

B. Equipment Access for Maintenance and Removal:

1. Install piping, equipment and accessories to permit access for maintenance as specified by the equipment manufacturer. Provide adequate clearance to disconnect equipment for removal. Locate valves and unions so additional piping removal is not necessary to remove equipment. Coordinate piping and equipment locations with all trades to ensure adequate clearance is maintained for equipment maintenance and removal.
2. Relocate items as necessary to provide access for maintenance and removal without additional cost to the Owner.

3.7 IDENTIFICATION OF PIPING, DUCTWORK AND EQUIPMENT:

- A. Piping: Install pipe and conduit identification markers in compliance with ANSI A13.1 on each side of wall penetrations, at each valve, at tee fittings, behind access panels and base of risers. Spacing of markers shall not exceed 20 feet and shall include at least one marker in each room. Ensure that markers are visible from 4 foot 6 inches to 6 feet above the finish floor.
 - 1. Install markers on painted piping only after painting is complete and has been accepted by the Architect. Install marker adjacent to access panels where piping is concealed.
- B. Ductwork: Stencil ductwork on both sides and bottom, and at each junction or branch takeoff. Provide identification stencil at least once in each room, and at intervals not longer than 20 ft. Stencil shall clearly identify duct service (S for supply, R for return, X for exhaust), are served by branch, and arrow indicating direction of flow.
- C. Equipment: Stencil equipment such as pumps, air handlers, water heaters, and tanks with the name of the equipment and equipment number. Coordinate equipment numbers with the Owner's maintenance personnel. Stencils shall be at least 6 inches high and of a color to provide a contrast with the equipment finish.
- D. Equipment markings shall be prominently displayed on each normally visible side of equipment. Equipment intended for installation in finished area shall have markings located behind normally used access panels mounted so as to be readily found. Equipment identification designations shall be taken from equipment schedules as indicated on the Drawings.

3.8 FIRE WATCH:

- A. Provide a fire watch as required by Division 1 when performing work, which may cause a fire, such as welding or torch cutting work.

3.9 SCAFFOLDING, HOISTING, RIGGING AND STAGING

- A. Provide scaffolding, hoisting, rigging, conveyance apparatus and staging in conformance with Division 1 as required to perform the work specified in the other mechanical sections of Division 23.

3.10 RECORD DOCUMENTS:

- A. Project Progress and Record Drawings: Comply with the appropriate Section of Division 1 governing Project Record Documents and the additional requirements of this Section.

1. Maintain a daily record of the project construction progress by coloring the work completed on the white prints furnished by the Owner at the commencement of the work.
 2. Modify the equipment schedules to reflect data consistent with that of the installed equipment. Clearly show all changes to the work as a result of addenda, change orders, clarifications, instructions issued by the Architect or conditions encountered in the field. Accurately indicate the location, size, type and elevation of new work and their relationship to existing work. Provide dimensions from permanent site improvements or column centerlines.
 3. The marked up and colored in prints will be used as a guide for determining the progress of the work installed. They shall be inspected weekly and shall be corrected immediately if found inaccurate or incomplete. Requisitions for Payment will not be approved until the Drawings are accurate and up-to-date.
- B. At the completion of the work submit one set of the marked up prints for review and acceptance. After acceptance, these marked up record prints shall be used to prepare the Owner's final Record Drawings.
- C. Maintain the established layering, color and pen thickness scheme on modified electronic drawing files.
- D. Make all modifications on the AutoCAD or Revit files indicated on the approved marked up set of Record Drawings. Remove all superseded data to show the completed installation.
- E. The final approved AutoCAD or Revit Record Drawing files shall become the property of the Owner.
- F. Deliver the completed Record Documents properly titled and dated to the Architect. These Record Documents shall become the property of the Owner.

3.11 SYSTEM START-UPS AND INSTRUCTIONS:

- A. Start-Ups: Perform system and equipment start-ups in accordance with the manufacturers' printed start-up instructions in the presence of the manufacturers' representatives.
1. Perform initial systems start up for all Life Safety Systems with the manufacturers' representatives and provide complete integrated systems testing and verification as detailed in the Fire Protection Narrative before notifying the approving Authorities having Jurisdiction. Make all

necessary adjustments, corrections and changes and retest the systems with the manufacturers' representatives present during the final testing and preliminary acceptance tests.

2. After the successful completion of all preliminary Life Safety Systems acceptance tests notify the approving Authorities having Jurisdiction.
3. Perform the final Life Safety Systems acceptance tests as detailed in the Fire Protection Narrative with the Manufacturers' Representatives, Authorities having Jurisdiction and Owner's Maintenance and Facility staff in attendance.

3.12 COMMISSIONING REQUIREMENTS:

- A. Systems furnished, installed and/or provided by Division 23 will be commissioned in accordance with IECC 2018 as modified by 780 CMR 13.
- B. Contractor shall provide the services of the Testing and Balancing subcontractor, the Building Controls subcontractor, Equipment Manufacturers' representatives, and his own personnel as required to operate, adjust, and calibrate equipment and systems and assist the Commissioning Agent in performing the services as specified in Section 23 80 00 Commissioning of HVAC.

3.13 CONSTRUCTION CERTIFICATIONS AND AFFIDAVITS:

- A. Engineer's Responsibility: During construction the Engineer is responsible for the following services as defined by the Massachusetts State Building Code, 780 CMR Section 116.2.2:
 1. Review, for conformance to the design concept, shop drawings, samples and other submittals, which are submitted by the contractor in accordance with the requirements of the construction documents.
 2. Review and approval of the quality control procedures for all code-required controlled materials.
 3. Be present at intervals appropriate to the stage of construction to become, generally familiar with the progress and quality of the work and to determine, in general, if the work is being performed in a manner consistent with the construction documents.
- B. Contractor's Responsibility: The Contractor is solely responsible for the completion of the work on schedule and in compliance with the Contract Documents and the applicable codes; and for scheduling sufficient time for all required testing and submissions and approvals.

1. Construction Affidavits: If upon the completion of the construction, the Building Official requires Affidavits from a Professional Engineer stating that the Contractor's work is in accordance with the approved construction documents and with applicable local, state and federal statutes and regulations as required by 780 CMR 116.3, the Contractor shall retain the services of a qualified Registered Professional Engineer to be on site during construction.
 2. Submission Schedule: Allow sufficient time for the initial submission; Architect/Engineer review; resubmission; and final review and approval of all documents required for acceptance of the request for a Certificate of Occupancy in accordance with 780 CMR 903.4.
 3. Testing Schedule: Allow sufficient time for the initial testing, adjustments, and final functional operational testing of all fire protection systems as outlined in the Fire Protection Narrative.
- C. Construction Certifications: After the Contractor submits signed Certifications of Compliance as required by the Massachusetts State Building Code, 780 CMR, Section 116.3, and complies with the requirements of 780 CMR 903.4, the responsible engineers will provide written certifications to confirm that to the best of the engineer's knowledge, information, and belief, the finished work is in compliance with the approved drawings issued for permit.
1. Prior to submission of the final signed Certifications of Compliance, the Contractor shall submit written responses to all punch list items submitted by the design team.
 2. The Engineer will not submit certifications until all required certifications of testing, compliance and completion of punch list items have been submitted to the Engineer.

3.14 ADDITIONAL REQUIREMENTS FOR THE COMPLETION OF THE PROJECT:

Ninth Edition 780 CMR 107.6 Construction Control Document

Construction Contractor Services Certification Pursuant to Section 107.6.3

Name of Contractor: _____

If a Corporation, name of responsible Corporate Officer:

If a DBA or Partnership, name of individual:

I hereby certify that, to the best of my knowledge and belief, construction performed under permit number _____ issued on _____ has been completed in substantial accord with the approved construction documents, with all pertinent deviations specifically noted per Section 107.6.3 of the Massachusetts State Building Code (780 CMR), 9th Edition Base Volume.

Name of Project: _____

Address of Project: _____

List of Pertinent Deviations:

Print Name: _____

Signature: _____

Date: _____

Notarized by: _____

Standard Notary Statement:

This document shall be submitted to the *Responsible Registered Design Professional* (RDP) and, when requested, to the Building Official in accordance with 780 CMR section 107.6.3 (9th edition) at the completion of all construction projects performed pursuant to 780 CMR Section 107.6 *Control Construction*.

REQUIREMENTS FOR THE ISSUE OF HVAC FINAL CONSTRUCTION AFFIDAVIT **Cover Sheet**

All required documents shall be provided as a single submission attached to this sign off sheet.

The Fire Protection Contractor shall provide notarized certificates of completion for the work done by the Contractor and each of the sub subs including but not limited to (form attached):			
	Attached (Y,N, NA)	Date	Signature
HVAC			
Sheetmetal			
Testing & Balancing			
Automatic Temperature Controls			
Other:			

Minimum documentation required			
	Attached (Y,N, NA)	Date	Signature
Approved pipe pressure test reports			
Approved duct leak test reports			
Approved Testing & Balancing Reports			
Approved As-Builts Signed by Contractor			
Fire chief signature for duct smoke detectors (by electrical)			
O&M manuals Check Off Sheet (form attached)			
Up to date monetized punch list			
Approved Cx on Gas detection system			
Approved Cx reports (attach approval cover page)			
Other:			

OPERATIONS & MAINTENANCE MANUALS CHECK LIST & SIGN OF COVER SHEET

	INITIAL
All O&M's shall be assembled with dividers with tabs.	
Dividers for equipment shall be sorted by Section Number.	
O&M manuals shall include the following:	
Table of Contents	
Warranties (including subcontractors)	
Contractor contact list, normal & emergency	
Vendor contact list	
1-year chemical treatment (only water systems)	
Valve tag chart	
Boiler inspection (if OWNER's insurance or state requires)	
All equipment in project	
Record drawings including the following:	
All ductwork, piping, and equipment location changes from the contract documents	
Updated schedules of actual equipment installed if different from contract documents	
Valve locations and valve tag numbers	
Equipment identification numbers	
Seismic restraint locations	

END OF SECTION

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT (FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.4 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: [**Class F**] <Insert class>.
- J. Code Letter Designation:
 - 1. Motors [**15**] <Insert number> HP and Larger: NEMA starting Code F or Code G.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Motors Smaller Than [15] <Insert number> HP: Manufacturer's standard starting characteristic.

- K. Enclosure Material: Cast iron for motor frame sizes [324T] <Insert number> and larger; rolled steel for motor frame sizes smaller than [324T] <Insert number>.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable-Frequency Controllers: [**Ratings, characteristics, and features coordinated with and approved by controller manufacturer.**]
 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 1. Permanent-split capacitor.
 2. Split phase.
 3. Capacitor start, inductor run.
 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 23 05 16

EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Flexible, ball-joint packed expansion joints.
2. Slip-joint, packed expansion joints.
3. Metal, compensator packless expansion joints.
4. Rubber union connector packless expansion joints.
5. Flexible-hose packless expansion joints.
6. Metal-bellows packless expansion joints.
7. Externally pressurized metal-bellows packless expansion joints.
8. Rubber packless expansion joints.
9. Grooved-joint expansion joints.
10. Alignment guides and anchors.
11. Pipe loops and swing connections.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKED EXPANSION JOINTS

- A. Flexible, Ball-Joint Packed Expansion Joints [**FBJ-01**] **<Insert drawing designation>**:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Standards: ASME Boiler and Pressure Vessel Code: Section II, "Materials"; ASME B31.9, "Building Services Piping," for materials and design of pressure-containing parts and bolting.
 - 3. Material: Carbon-steel assembly with asbestos-free composition packing.
 - 4. Design: Provide 360-degree rotation and angular deflection.
 - 5. Minimum Pressure Rating: [**250 psig at 400 deg F**] **<Insert value>**.
 - 6. Angular Deflection for NPS 6 and Smaller: 30 degree minimum.
 - 7. Angular Deflection for NPS 8 and Larger: 15 degree minimum.
 - 8. Seal Type: Two carbon steel and graphite seals suitable for continuous operation at temperature up to 650 deg F.
 - 9. Internal Ball: Plated with minimum 1-mil chrome cover.
 - 10. Ball Socket: One- or two-piece design with integral socket/retainer.

- a. Stuffing Box: Incorporates containment seals and compression seals for containment of injectable packing.
 - b. Packing Cylinders: Provides packing under full line pressure with check valves to prevent blowback.
- 11. End Connections for NPS 2 and Smaller: Threaded.
- 12. End Connections for NPS 2-1/2 and Larger: Flanged.
- B. Slip-Joint Packed Expansion Joints [SJ-01] <Insert drawing designation>:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Standard: ASTM F1007.
 - 3. Material: Carbon steel with asbestos-free PTFE packing.
 - 4. Design: With internal guide and injection ports for repacking under full system pressure. Housing shall be furnished with drain ports and lifting ring. Include drip connection if used for steam piping.
 - 5. Configuration: [Single joint] [Single joint with base] [and] [double joint with base] class(es), unless otherwise indicated.
 - 6. Slip Tube for sizes NPS 1-1/2 through NPS 16: Schedule 80.
 - 7. Slip Tube for sizes NPS 18 through NPS 24: Schedule 60.
 - 8. Sliding Surface: 2 mil thick chrome finish.
 - 9. End Connections: Flanged or welded ends to match piping system.

2.3 PACKLESS EXPANSION JOINTS

- A. Metal, Compensator Packless Expansion Joints [MCEJ-01] <Insert drawing designation>:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Minimum Pressure Rating: [150 psig] [175 psig] [200 psig] <Insert value>, unless otherwise indicated.
 - 3. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
 - 4. Joint Axial Movement: 2-inches of compression and 1/2-inch of extension.
 - 5. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.
 - a. End Connections for Copper Tubing NPS 2 and Smaller: [Solder joint] [or] [threaded].
 - b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Threaded.
 - 6. Configuration for Steel Piping: Multi-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.
 - a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.

- b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: [**Flanged**] [**Threaded**] [**Welded**].
- B. Rubber Union Connector Expansion Joints [**RUEJ-01**] <Insert drawing designation>:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Material: Twin reinforced-rubber spheres[**with external restraining cables**].
 - 3. Minimum Pressure Rating: [**150 psig at 170 deg F**] <Insert value>, unless otherwise indicated.
 - 4. End Connections for NPS 2 and Smaller: Threaded.
- C. Flexible-Hose Packless Expansion Joints [**FHEJ-01**] <Insert drawing designation>:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
 - 3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
 - 4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with [**solder-joint**] <Insert type> end connections.
 - a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
 - b. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.
 - 5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with [**threaded**] <Insert type> end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.
 - 6. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psig at 600 deg F ratings.
 - 7. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with [**flanged**] [**welded**] end connections.

- a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.
- 8. Expansion Joints for Steel Piping NPS 8 to NPS 12: Carbon-steel fittings with **[flanged]** **[welded]** end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.
- 9. Expansion Joints for Steel Piping NPS 14 and Larger: Carbon-steel fittings with **[flanged]** **[welded]** end connections.
 - a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.
- D. Metal-Bellows Packless Expansion Joints **[MBEJ-01]** **<Insert drawing designation>**:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Standards: ASTM F1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
 - 3. Type: Circular, corrugated bellows[**with external tie rods**].
 - 4. Minimum Pressure Rating: **[150 psig]** **[175 psig]** **[200 psig]** **<Insert value>**, unless otherwise indicated.
 - 5. Configuration: **[Single joint]** **[Single joint with base]** **[and]** **[double joint with base]** class(es), unless otherwise indicated.
 - 6. Expansion Joints for Copper Tubing: **[Single-]** **[or]** **[multi-]**ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
 - a. End Connections for Copper Tubing NPS 2 and Smaller: **[Solder joint]** **[or]** **[threaded]**.
 - b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: **[Solder joint]** **[or]** **[threaded]**.
 - c. End Connections for Copper Tubing NPS 5 and Larger: Flanged.
 - 7. Expansion Joints for Steel Piping: **[Single-]** **[or]** **[multi-]**ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.
 - a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
 - b. End Connections for Steel Pipe NPS 2-1/2 and Larger: **[Flanged]** **[Welded]**.
- E. Externally Pressurized Metal-Bellows Packless Expansion Joints **[EPEJ-01]** **<Insert drawing designation>**:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Minimum Pressure Rating: [150 psig] [200 psig] [300 psig] <Insert value>, unless otherwise indicated.
3. Description:
 - a. Totally enclosed, externally pressurized, multi-ply, stainless-steel bellows isolated from fluid flow by an internal pipe sleeve.
 - b. Carbon-steel housing.
 - c. Drain plugs and lifting lug for the NPS 3 and larger.
 - d. Bellows shall have operating clearance between the internal pipe sleeves and the external shrouds.
 - e. Joints shall be supplied with a built-in scale to confirm the starting position and operating movement.
 - f. Joint Axial Movement: [4-inches] [6-inches] [8-inches] <Insert compression limit> of compression and [0.75-inch] [1-inch] [2-inches] <Insert extension limit> of extension.
4. Permanent Locking Bolts: Set locking bolts to maintain joint lengths during installation. Temporary welding tabs that are removed after installation in lieu of locking bolts are not acceptable.
5. End Connection Configuration: Flanged; one raised, fixed and one floating flange.

F. Rubber Packless Expansion Joints [REJ-01] <Insert drawing designation>:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Standards: ASTM F1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
3. Material: Fabric-reinforced rubber complying with FSA-PSJ-703.
4. Arch Type: [Single] [or] [multiple] arches[with external control rods].
5. Spherical Type: [Single] [or] [multiple] spheres[with external control rods].
6. Minimum Pressure Rating for NPS 1-1/2 to NPS 4: [150 psig at 220 deg F] <Insert value>.
7. Minimum Pressure Rating for NPS 5 and NPS 6: [140 psig at 200 deg F] <Insert value>.
8. Minimum Pressure Rating for NPS 8 to NPS 12: [140 psig at 180 deg F] <Insert value>.
9. Material for Fluids Containing Acids, Alkalis, or Chemicals: [Butyl rubber] [Chlorosulfonyl-polyethylene rubber] [Ethylene-propylene-diene terpolymer rubber] <Insert material>.
10. Material for Fluids Containing Gas, Hydrocarbons, or Oil: [Buna-N] [Chlorosulfonated polyethylene synthetic rubber] <Insert material>.
11. Material for Water: [Butyl rubber] [Buna-N] [Chlorosulfonated polyethylene synthetic rubber] [Chlorosulfonyl-polyethylene rubber] [Ethylene-propylene-diene terpolymer rubber] [Natural rubber].
12. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.4 GROOVED-JOINT EXPANSION JOINTS

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
- C. Standard: AWWA C606, for grooved joints.
- D. Nipples: [**Galvanized**,]ASTM A53/A53M, Schedule 40, Type E or S, steel pipe with grooved ends.
- E. Couplings: [**Five**] [**Seven**] [**10**] [**12**] **<Insert number>**, flexible type for steel-pipe dimensions. Include ferrous housing sections, [**Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water**] [**ethylene-propylene-diene terpolymer rubber gasket suitable for cold and hot water**], and bolts and nuts.

2.5 ALIGNMENT GUIDES AND ANCHORS

- A. Alignment Guides [**AG-01**] **<Insert drawing designation>**:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.
- B. Anchor Materials:
 - 1. Steel Shapes and Plates: ASTM A36/A36M.
 - 2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
 - 3. Washers: ASTM F844, steel, plain, flat washers.
 - 4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.
 - 5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

- b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
- c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install packed-type expansion joints with packing suitable for fluid service.
- C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
- D. Install rubber packless expansion joints according to FSA-PSJ-703.
- E. Install grooved-joint expansion joints to grooved-end steel piping.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- B. Connect risers and branch connections to mains with at least **[five]** **<Insert number>** pipe fittings, including tee in main.
- C. Connect risers and branch connections to terminal units with at least **[four]** **<Insert number>** pipe fittings, including tee in riser.
- D. Connect mains and branch connections to terminal units with at least **[four]** **<Insert number>** pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install **[one]** **[two]** guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than **[four]** **<Insert number>** pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.

- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

SECTION 23 05 17

SLEEVES AND SLEEVE SEALS FOR HVAC PIPING (FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 – HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contracts, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of the Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections:

Section 07 92 00 – JOINT SEALANTS

Section 07 84 13 – PENETRATION FIRESTOPPING

1.3 SUMMARY:

- A. Section Includes:

- 1. Sleeves.
- 2. Stack-sleeve fittings.
- 3. Sleeve-seal systems.
- 4. Sleeve-seal fittings.
- 5. Grout.

1.4 ACTION SUBMITTALS:

- A. Product Data: For each type of product indicated.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

PART 2 - PRODUCTS

2.1 SLEEVES:

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 1. Sealing Elements: [**EPDM-rubber**] [**NBR**] interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: [**Carbon steel**] [**Plastic**] [**Stainless steel**].
 - 3. Connecting Bolts and Nuts: [**Carbon steel, with corrosion-resistant coating,**] [**Stainless steel**] of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT:

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION:

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide [1-inch] <Insert dimension> annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas [2 inches] <Insert dimension> above finished floor level.
 - 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 92 00 "Joint Sealants."

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 13 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION:

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
 - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION:

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION:

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE:

- A. Use sleeves and sleeve seals for the following piping-penetration applications:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than [NPS 6] **<Insert pipe size>**: [Cast-iron wall sleeves] [Galvanized-steel wall sleeves] [Galvanized-steel-pipe sleeves] [Sleeve-seal fittings] **<Insert material>**.
 - b. Piping [NPS 6] **<Insert pipe size>** and Larger: [Cast-iron wall sleeves] [Galvanized-steel wall sleeves] [Galvanized-steel-pipe sleeves] **<Insert material>**.
2. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than [NPS 6] **<Insert pipe size>**: [Cast-iron wall sleeves with sleeve-seal system] [Galvanized-steel wall sleeves with sleeve-seal system] [Galvanized-steel-pipe sleeves with sleeve-seal system] [Sleeve-seal fittings] **<Insert material>**.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping [NPS 6] **<Insert pipe size>** and Larger: [Cast-iron wall sleeves with sleeve-seal system] [Galvanized-steel wall sleeves with sleeve-seal system] [Galvanized-steel-pipe sleeves with sleeve-seal system] **<Insert material>**.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than [NPS 6] **<Insert pipe size>**: [Cast-iron wall sleeves with sleeve-seal system] [Galvanized-steel wall sleeves with sleeve-seal system] [Galvanized-steel-pipe sleeves with sleeve-seal system] [Sleeve-seal fittings] **<Insert material>**.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping [NPS 6] **<Insert pipe size>** and Larger: [Cast-iron wall sleeves with sleeve-seal system] [Galvanized-steel wall sleeves with sleeve-seal system] [Galvanized-steel-pipe sleeves with sleeve-seal system] [Galvanized-steel-pipe sleeves] **<Insert material>**.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
 - a. Piping Smaller Than [NPS 6] **<Insert pipe size>**: [Galvanized-steel-pipe sleeves] [PVC-pipe sleeves] [Stack-sleeve fittings] [Sleeve-seal fittings] [Molded-PE or -PP sleeves] [Molded-PVC sleeves] **<Insert material>**.
 - b. Piping [NPS 6] **<Insert pipe size>** and Larger: [Galvanized-steel-pipe sleeves] [PVC-pipe sleeves] [Stack-sleeve fittings] **<Insert material>**.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

5. Interior Partitions:

- a. Piping Smaller Than [NPS 6] <Insert pipe size>: [Galvanized-steel-pipe sleeves] [PVC-pipe sleeves] <Insert material>.
- b. Piping [NPS 6] <Insert pipe size> and Larger: [Galvanized-steel-sheet sleeves] <Insert material>.

END OF SECTION

SECTION 23 05 19

METERS AND GAGES FOR HVAC PIPING
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections:

Section 23 11 23 – FACILITY NATURAL-GAS PIPING

Section 23 22 16 – STEAM AND CONDENSATE PIPING SPECIALTIES

1.3 SUMMARY:

- A. Section Includes:
 - 1. Bimetallic-actuated thermometers.
 - 2. Filled-system thermometers.
 - 3. Liquid-in-glass thermometers.
 - 4. Light-activated thermometers.
 - 5. Duct-thermometer mounting brackets.
 - 6. Thermowells.
 - 7. Dial-type pressure gages.
 - 8. Gage attachments.
 - 9. Test plugs.
 - 10. Test-plug kits.
 - 11. Sight flow indicators.
 - 12. Flowmeters.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

13. Thermal-energy meters.

1.4 ACTION SUBMITTALS:

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS:

- A. Product Certificates: For each type of meter and gage.

1.6 CLOSEOUT SUBMITTALS:

- A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Standard: ASME B40.200.
- C. Case: [**Liquid-filled**] [**and**] [**sealed**] type(s); stainless steel with [**3-inch**] [**5-inch**] **<Insert dimension>** nominal diameter.
- D. Dial: [**Nonreflective aluminum**] **<Insert material>** with permanently etched scale markings and scales in [**deg. F**] [**deg. F and deg. C**].
- E. Connector Type(s): Union joint, [**adjustable angle**] [**rigid, back**] [**and**] [**rigid, bottom**] **<Insert type>**, with unified-inch screw threads.
- F. Connector Size: [**1/2-inch**] **<Insert dimension>**, with ASME B1.1 screw threads.
- G. Stem: 0.25 or 0.375-inch in diameter; stainless steel.
- H. Window: [**Plain glass**] [**or**] [**plastic**] **<Insert material>**.
- I. Ring: Stainless steel.
- J. Element: Bimetal coil.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- K. Pointer: Dark-colored metal.
- L. Accuracy: Plus or minus [1] [1.5] <Insert number> percent of scale range.

2.2 FILLED-SYSTEM THERMOMETERS:

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Standard: ASME B40.200.
3. Case: Sealed type, [cast aluminum or drawn steel] <Insert material>; [4-1/2-inch] [5-inch] [6-inch] <Insert dimension> nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, [dampening type,] with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in [deg. F] [deg. F and deg. C].
7. Pointer: Dark-colored metal.
8. Window: [Glass] [or] [plastic] <Insert material>.
9. Ring: [Metal] [Stainless steel] <Insert material>.
10. Connector Type(s): Union joint, [adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device] [rigid, back] [and] [rigid, bottom]; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
12. Accuracy: Plus or minus [1] <Insert number> percent of scale range.

B. Direct-Mounted, Plastic-Case, Vapor-Actuated Thermometers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Standard: ASME B40.200.
3. Case: Sealed type, [plastic] <Insert material>; [4-1/2-inch] [5-inch] [6-inch] <Insert dimension> nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in [deg. F] [deg. F and deg. C].
7. Pointer: Dark-colored metal.
8. Window: [Glass] [or] [plastic] <Insert material>.
9. Ring: [Metal] [or] [plastic] <Insert material>.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

10. Connector Type(s): Union joint, [**adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device**] [**rigid, back**] [**and**] [**rigid, bottom**]; with ASME B1.1 screw threads.
 11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
 12. Accuracy: Plus or minus [**1**] **<Insert number>** percent of scale range.
- C. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Standard: ASME B40.200.
 3. Case: Sealed type, [**cast aluminum or drawn steel**] **<Insert material>**; [**4-1/2-inch**] [**6-inch**] **<Insert dimension>** nominal diameter with [**back**] [**front**] flange and holes for panel mounting.
 4. Element: Bourdon tube or other type of pressure element.
 5. Movement: Mechanical, with link to pressure element and connection to pointer.
 6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in [**deg. F**] [**deg. F and deg. C**].
 7. Pointer: Dark-colored metal.
 8. Window: [**Glass**] [**or**] [**plastic**] **<Insert material>**.
 9. Ring: [**Metal**] [**Stainless steel**] **<Insert material>**.
 10. Connector Type(s): Union joint, [**back**] [**bottom**]; with ASME B1.1 screw threads.
 11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
 12. Accuracy: Plus or minus [**1**] **<Insert number>** percent of scale range.
- D. Remote-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Standard: ASME B40.200.
 3. Case: Sealed type, [**plastic**] **<Insert material>**; [**4-1/2-inch**] [**6-inch**] **<Insert dimension>** nominal diameter with [**back**] [**front**] flange and holes for panel mounting.
 4. Element: Bourdon tube or other type of pressure element.
 5. Movement: Mechanical, with link to pressure element and connection to pointer.
 6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in [**deg. F**] [**deg. F and deg. C**].

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

7. Pointer: Dark-colored metal.
8. Window: **[Glass]** **[or]** **[plastic]** **<Insert material>**.
9. Ring: **[Metal]** **[or]** **[plastic]** **<Insert material>**.
10. Connector Type(s): Union joint, threaded, **[back]** **[bottom]**; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
12. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 LIQUID-IN-GLASS THERMOMETERS:

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Standard: ASME B40.200.
3. Case: **[Cast aluminum]** **<Insert material>**; 6-inch nominal size.
4. Case Form: **[Back angle]** **[Straight]** unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue **[or red]** organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in **[deg. F]** **[deg. F and deg. C]**.
7. Window: Glass or plastic.
8. Stem: Aluminum or brass and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
9. Connector: $\frac{3}{4}$ -inch, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Standard: ASME B40.200.
3. Case: **[Plastic]** **<Insert material>**; 6-inch nominal size.
4. Case Form: **[Back angle]** **[Straight]** unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue **[or red]** organic liquid.
6. Tube Background: Nonreflective with permanently etched scale markings graduated in **[deg. F]** **[deg. F and deg. C]**.
7. Window: Glass or plastic.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

8. Stem: Aluminum or brass and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
9. Connector: $\frac{3}{4}$ -inch, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

C. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Standard: ASME B40.200.
3. Case: [**Cast aluminum**] **<Insert material>**; [**7-inch**] [**9-inch**] nominal size unless otherwise indicated.
4. Case Form: [**Adjustable angle**] [**Back angle**] [**Straight**] **<Insert form>** unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue [**or red**] organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in [**deg. F**] [**deg. F and deg. C**].
7. Window: [**Glass**] [**or**] [**plastic**] **<Insert material>**.
8. Stem: [**Aluminum**] **<Insert material>** and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4-inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

D. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Standard: ASME B40.200.
3. Case: [**Plastic**] **<Insert material>**; [**7-inch**] [**9-inch**] nominal size unless otherwise indicated.
4. Case Form: [**Adjustable angle**] [**Back angle**] [**Straight**] **<Insert form>** unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue [**or red**] organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in [**deg. F**] [**deg. F and deg. C**].
7. Window: [**Glass**] [**or**] [**plastic**] **<Insert material>**.
8. Stem: [**Aluminum**] [**Brass**] [**Stainless steel**] [**Aluminum, brass, or stainless steel**] **<Insert material>** and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- b. Design for Thermowell Installation: Bare stem.
- 9. Connector: 1-1/4-inches, with ASME B1.1 screw threads.
- 10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.4 LIGHT-ACTIVATED THERMOMETERS:

A. Direct-Mounted, Light-Activated Thermometers:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Case: [Plastic] [Metal] <Insert material>; [7-inch] [9-inch] nominal size unless otherwise indicated.
- 3. Scale(s): [Deg. F] [Deg. F and deg. C].
- 4. Case Form: [Adjustable angle] <Insert form>.
- 5. Connector: [1-1/4-inches] <Insert dimension>, with ASME B1.1 screw threads.
- 6. Stem: [Aluminum] <Insert material> and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
- 7. Display: Digital.
- 8. Accuracy: Plus or minus 2 deg. F.

B. Remote-Mounted, Light-Activated Thermometers:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Case: Plastic, for wall mounting.
- 3. Scale(s): [Deg. F] [Deg. F and deg. C].
- 4. Sensor: Bulb and thermister wire.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
- 5. Display: Digital.
- 6. Accuracy: Plus or minus 2 deg. F.

2.5 DUCT-THERMOMETER MOUNTING BRACKETS:

- A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.6 THERMOWELLS:

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: [CNR] [or] [CUNI] <Insert material>.
4. Material for Use with Steel Piping: [CRES] [CSA] <Insert material>.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1-inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: [Mixture of graphite and glycerin] <Insert material>.

2.7 DIAL-TYPE PRESSURE GAGES:

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Standard: ASME B40.100.
3. Case: [Liquid-filled] [Sealed] [Open-front, pressure relief] [Solid-front, pressure relief] <Insert type> type(s); [cast aluminum or drawn steel] <Insert material>; [4-1/2-inch] [6-inch] <Insert dimension> nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with [NPS 1/4] [NPS 1/4 or NPS 1/2] [NPS 1/2], ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in [psi] [psi and kPa].
8. Pointer: Dark-colored metal.
9. Window: [Glass] [or] [plastic] <Insert material>.
10. Ring: [Metal] [Brass] [Stainless steel].
11. Accuracy: [Grade A, plus or minus 1 percent of middle half of] [Grade B, plus or minus 2 percent of middle half of] [Grade C, plus or minus 3 percent of middle half of] [Grade D, plus or minus 5 percent of whole] scale range.

B. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Standard: ASME B40.100.
3. Case: [Sealed] <Insert type> type; [plastic] <Insert material>; [4-1/2-inch] [6-inch] <Insert dimension> nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with [NPS 1/4] [NPS 1/4 or NPS 1/2] [NPS 1/2], ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in [psi] [psi and kPa].
8. Pointer: Dark-colored metal.
9. Window: [Glass] [or] [plastic] <Insert material>.
10. Accuracy: [Grade A, plus or minus 1 percent of middle half of] [Grade B, plus or minus 2 percent of middle half of] [Grade C, plus or minus 3 percent of middle half of] [Grade D, plus or minus 5 percent of whole] scale range.

C. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Standard: ASME B40.100.
3. Case: [Liquid-filled] [Sealed] <Insert type> type; [cast aluminum or drawn steel] [metal] <Insert material>; [4-1/2-inch] [6-inch] <Insert dimension> nominal diameter with [back] [front] flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with [NPS 1/4] [NPS 1/4 or NPS 1/2] [NPS 1/2], ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in [psi] [psi and kPa].
8. Pointer: Dark-colored metal.
9. Window: [Glass] [or] [plastic] <Insert material>.
10. Ring: [Metal] [Stainless steel] <Insert material>.
11. Accuracy: [Grade A, plus or minus 1 percent of middle half of] [Grade B, plus or minus 2 percent of middle half of] [Grade C, plus or minus 3 percent of middle half of] [Grade D, plus or minus 5 percent of whole] scale range.

D. Remote-Mounted, Plastic-Case, Dial-Type Pressure Gages:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Standard: ASME B40.100.

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3. Case: [Sealed] <Insert type> type; [plastic] <Insert material>; [4-1/2-inch] [6-inch] <Insert dimension> nominal diameter with [back] [front] flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with [NPS 1/4] [NPS 1/4 or NPS 1/2] [NPS 1/2], ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in [psi] [psi and kPa].
8. Pointer: Dark-colored metal.
9. Window: [Glass] [or] [plastic] <Insert material>.
10. Accuracy: [Grade A, plus or minus 1 percent of middle half of] [Grade B, plus or minus 2 percent of middle half of] [Grade C, plus or minus 3 percent of middle half of] [Grade D, plus or minus 5 percent of whole] scale range.

2.8 GAGE ATTACHMENTS:

- A. Snubbers: ASME B40.100, brass; with [NPS 1/4] [NPS 1/4 or NPS 1/2] [NPS 1/2], ASME B1.20.1 pipe threads and [piston] [porous-metal]-type surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Loop-shaped section of [brass] [stainless-steel] [steel] pipe with [NPS 1/4] [NPS 1/4 or NPS 1/2] [NPS 1/2] pipe threads.
- C. Valves: [Brass ball] [Brass or stainless-steel needle], with [NPS 1/4] [NPS 1/4 or NPS 1/2] [NPS 1/2], ASME B1.20.1 pipe threads.

2.9 TEST PLUGS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Test-station fitting made for insertion in piping tee fitting.
- C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
- D. Thread Size: [NPS 1/4] [or] [NPS 1/2], ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: [500 psig at 200 deg. F] <Insert ratings>.
- F. Core Inserts: [Chlorosulfonated polyethylene synthetic] [and] [EPDM] self-sealing rubber.

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2.10 TEST-PLUG KITS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Furnish [**one**] **<Insert number>** test-plug kit(s) containing [**one**] [**two**] thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.
- C. Low-Range Thermometer: Small, bimetallic insertion type with [**1- to 2-inch-**] **<Insert dimension>** diameter dial and tapered-end sensing element. Dial range shall be at least [**25 to 125 deg. F**] **<Insert temperature range>**.
- D. High-Range Thermometer: Small, bimetallic insertion type with [**1- to 2-inch-**] **<Insert dimension>** diameter dial and tapered-end sensing element. Dial range shall be at least [**0 to 220 deg. F**] **<Insert temperature range>**.
- E. Pressure Gage: Small, Bourdon-tube insertion type with [**2- to 3-inch-**] **<Insert dimension>** diameter dial and probe. Dial range shall be at least [**0 to 200 psig**] **<Insert range>**.
- F. Carrying Case: Metal or plastic, with formed instrument padding.

2.11 SIGHT FLOW INDICATORS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Piping inline-installation device for visual verification of flow.
- C. Construction: Bronze or stainless-steel body, with sight glass and [**ball, flapper, or paddle wheel**] **<Insert device>** indicator, and threaded or flanged ends.
- D. Minimum Pressure Rating: [**125 psig**] [**150 psig**] **<Insert value>**.
- E. Minimum Temperature Rating: [**200 deg. F**] **<Insert temperature>**.
- F. End Connections for NPS 2 and Smaller: Threaded.
- G. End Connections for NPS 2-1/2 and Larger: Flanged.

2.12 FLOWMETERS:

- A. Orifice Flowmeters:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Description: Flowmeter with sensor, hoses or tubing, fittings, valves, indicator, and conversion chart.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Wafer-orifice-type, calibrated, flow-measuring element; for installation between pipe flanges.
 - a. Design: Differential-pressure-type measurement for [gas] [oil] [steam] [water] <Insert fluid>.
 - b. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
 - c. Minimum Pressure Rating: [300 psig] <Insert value>.
 - d. Minimum Temperature Rating: [250 deg. F] <Insert temperature>.
5. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected sensor and having 6-inch-diameter, or equivalent, dial with fittings and copper tubing for connecting to sensor.
 - a. Scale: Gallons per minute.
 - b. Accuracy: Plus or minus [1 percent between 20 and 80 percent of scale range] <Insert accuracy>.
6. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected sensor and having two 12-foot hoses, with carrying case.
 - a. Scale: Gallons per minute.
 - b. Accuracy: Plus or minus [2 percent between 20 and 80 percent of scale range] <Insert accuracy>.
7. Display: Shows rate of flow [, with register to indicate total volume in gallons].
8. Conversion Chart: Flow rate data compatible with sensor and indicator.
9. Operating Instructions: Include complete instructions with each flowmeter.

B. Pitot-Tube Flowmeters:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description: Flowmeter with sensor and indicator.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Insertion type; for inserting probe in piping and measuring flow directly in gallons per minute.
 - a. Design: Differential-pressure-type measurement for [oil] [water] <Insert fluid>.
 - b. Construction: Stainless-steel probe of length to span inside of pipe, with integral transmitter and direct-reading scale.
 - c. Minimum Pressure Rating: [150 psig] <Insert value>.

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- d. Minimum Temperature Rating: [250 deg. F] <Insert temperature>.
 5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
 6. Integral Transformer: For low-voltage power connection.
 7. Accuracy: Plus or minus [3] <Insert number> percent.
 8. Display: Shows rate of flow [, **with register to indicate total volume in gallons**].
 9. Operating Instructions: Include complete instructions with each flowmeter.
- C. Turbine Flowmeters:
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Description: Flowmeter with sensor and indicator.
 3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
 4. Sensor: Impeller turbine; for inserting in pipe fitting or for installing in piping and measuring flow directly in gallons per minute.
 - a. Design: Device or pipe fitting with inline turbine and integral direct-reading scale for [gas] [oil] [steam] [water] <Insert fluid>.
 - b. Construction: Bronze or stainless-steel body, with plastic turbine or impeller.
 - c. Minimum Pressure Rating: [150 psig] <Insert value>.
 - d. Minimum Temperature Rating: [180 deg. F] <Insert temperature>.
 5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
 6. Accuracy: Plus or minus [1-1/2] <Insert number> percent.
 7. Display: Shows rate of flow [, **with register to indicate total volume in gallons**].
 8. Operating Instructions: Include complete instructions with each flowmeter.
- D. Venturi Flowmeters:
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
 3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
 4. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.
 - a. Design: Differential-pressure-type measurement for [gas] [oil] [steam] [water] <Insert fluid>.
 - b. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
 - c. Minimum Pressure Rating: [250 psig] <Insert value>.
 - d. Minimum Temperature Rating: [250 deg. F] <Insert temperature>.
 - e. End Connections for NPS 2 and Smaller: Threaded.

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- f. End Connections for NPS 2-1/2 and Larger: Flanged or welded.
 - g. Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.
 - 5. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch-diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
 - a. Scale: Gallons per minute.
 - b. Accuracy: Plus or minus [**1 percent between 20 and 80 percent of scale range**] **<Insert accuracy>**.
 - 6. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected flowmeter element and having two 12-foot hoses, with carrying case.
 - a. Scale: Gallons per minute.
 - b. Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.
 - 7. Display: Shows rate of flow [, **with register to indicate total volume in gallons**].
 - 8. Conversion Chart: Flow rate data compatible with sensor.
 - 9. Operating Instructions: Include complete instructions with each flowmeter.
- E. Vortex-Shedding Flowmeters:
- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Description: Flowmeter with sensor and indicator.
 - 3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
 - 4. Sensor: Inline type; for installing between pipe flanges and measuring flow directly in gallons per minute.
 - a. Design: Flow obstruction device, vortex-measurement type for [**gas**] [**steam**] [**and**] [**liquids**].
 - b. Construction: Stainless-steel body, with integral transmitter and direct-reading scale.
 - c. Minimum Pressure Rating: [**1000 psig**] **<Insert value>**.
 - d. Minimum Temperature Rating: [**500 deg. F**] **<Insert temperature>**.
 - e. Integral Transformer: For low-voltage power operation.
 - 5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
 - 6. Accuracy: Plus or minus [**0.25**] **<Insert number>** percent for liquids and [**0.75**] **<Insert number>** percent for gases.
 - 7. Display: Shows rate of flow [, **with register to indicate total volume in gallons**].
 - 8. Operating Instructions: Include complete instructions with each flowmeter.

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2.13 THERMAL-ENERGY METERS:

A. Impeller-Turbine, Thermal-Energy Meters:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description: System with [**strainer,**] flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
3. Flow Sensor: Impeller turbine with corrosion-resistant-metal body and transmitter; for installing in piping.
 - a. Design: Total thermal-energy measurement.
 - b. Minimum Pressure Rating: [**150 psig**] **<Insert value>**.
 - c. Minimum Temperature Range: [**40 to 250 deg. F**] **<Insert temperature range>**.
4. Temperature Sensors: Insertion-type transducer.
5. Indicator: Solid-state, integrating-type meter [**with integral battery pack**]; for wall mounting.
 - a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
 - b. Battery Pack: Five-year lithium battery.
6. Accuracy: Plus or minus [**1**] **<Insert number>** percent.
7. Display: Visually indicates total fluid volume in gallons and thermal-energy flow in kilowatts per hour or British thermal units.
8. Strainer: Full size of main line piping.
9. Operating Instructions: Include complete instructions with each thermal-energy meter system.

B. Ultrasonic, Thermal-Energy Meters:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description: Meter with flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
3. Flow Sensor: Transit-time ultrasonic type with transmitter.
4. Temperature Sensors: Insertion-type or strap-on transducer.
5. Indicator: Solid-state, integrating-type meter [**with integral battery pack**].
 - a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
 - b. Battery Pack: Five-year lithium battery.
6. Accuracy: Plus or minus [**1**] **<Insert number>** percent.
7. Display: Visually indicates total fluid volume in gallons and thermal-energy flow in kilowatts per hour or British thermal units.

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8. Operating Instructions: Include complete instructions with each thermal-energy meter system.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Install thermowells with socket extending [**a minimum of 2-inches into fluid**] [**one-third of pipe diameter**] [**to center of pipe**] and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
- H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- I. Install remote-mounted pressure gages on panel.
- J. Install valve and snubber in piping for each pressure gage for fluids (except steam).
- K. Install valve and syphon fitting in piping for each pressure gage for steam.
- L. Install test plugs in piping tees.
- M. Install flow indicators in piping systems in accessible positions for easy viewing.
- N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
- O. Install flowmeter elements in accessible positions in piping systems.
- P. Install wafer-orifice flowmeter elements between pipe flanges.

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- Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.
- R. Install permanent indicators on walls or brackets in accessible and readable positions.
- S. Install connection fittings in accessible locations for attachment to portable indicators.
- T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.
- U. Install thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler.
 - 3. Two inlets and two outlets of each chiller.
 - 4. Inlet and outlet of each hydronic coil in air-handling units.
 - 5. Two inlets and two outlets of each hydronic heat exchanger.
 - 6. Inlet and outlet of each thermal-storage tank.
 - 7. Outside-, return-, supply-, and mixed-air ducts.
 - 8. **<Insert location>**.
- V. Install pressure gages in the following locations:
 - 1. Discharge of each pressure-reducing valve.
 - 2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
 - 3. Suction and discharge of each pump.
 - 4. **<Insert location>**.

3.2 CONNECTIONS:

- A. Install meters and gages adjacent to machines and equipment to allow space for service and maintenance of meters, gages, machines, and equipment.
- B. Connect flowmeter-system elements to meters.
- C. Connect flowmeter transmitters to meters.
- D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING:

- A. After installation, calibrate meters according to manufacturer's written instructions.
- B. Adjust faces of meters and gages to proper angle for best visibility.

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3.4 THERMOMETER SCHEDULE:

- A. Thermometers at inlet and outlet of each hydronic zone shall be [**one of**] the following:
1. [Liquid-filled] [Sealed], bimetallic-actuated type.
 2. [Direct] [Remote]-mounted, [metal] [plastic]-case, vapor-actuated type.
 3. [Compact] [Industrial]-style, liquid-in-glass type.
 4. [Direct] [Remote]-mounted, light-activated type.
 5. Test plug with [chlorosulfonated polyethylene synthetic] [EPDM] self-sealing rubber inserts.
- B. Thermometers at inlet and outlet of each hydronic boiler shall be [**one of**] the following:
1. [Liquid-filled] [Sealed], bimetallic-actuated type.
 2. [Direct] [Remote]-mounted, [metal] [plastic]-case, vapor-actuated type.
 3. [Compact] [Industrial]-style, liquid-in-glass type.
 4. [Direct] [Remote]-mounted, light-activated type.
 5. Test plug with [chlorosulfonated polyethylene synthetic] [EPDM] self-sealing rubber inserts.
- C. Thermometers at inlets and outlets of each chiller shall be [**one of**] the following:
1. [Liquid-filled] [Sealed], bimetallic-actuated type.
 2. [Direct] [Remote]-mounted, [metal] [plastic]-case, vapor-actuated type.
 3. [Compact] [Industrial]-style, liquid-in-glass type.
 4. [Direct] [Remote]-mounted, light-activated type.
 5. Test plug with [chlorosulfonated polyethylene synthetic] [EPDM] self-sealing rubber inserts.
- D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be [**one of**] the following:
1. [Liquid-filled] [Sealed], bimetallic-actuated type.
 2. [Direct] [Remote]-mounted, [metal] [plastic]-case, vapor-actuated type.
 3. [Compact] [Industrial]-style, liquid-in-glass type.
 4. [Direct] [Remote]-mounted, light-activated type.
 5. Test plug with [chlorosulfonated polyethylene synthetic] [EPDM] self-sealing rubber inserts.
- E. Thermometers at inlets and outlets of each hydronic heat exchanger shall be [**one of**] the following:
1. [Liquid-filled] [Sealed], bimetallic-actuated type.
 2. [Direct] [Remote]-mounted, [metal] [plastic]-case, vapor-actuated type.
 3. [Compact] [Industrial]-style, liquid-in-glass type.
 4. [Direct] [Remote]-mounted, light-activated type.

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5. Test plug with [**chlorosulfonated polyethylene synthetic**] [**EPDM**] self-sealing rubber inserts.
 - F. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be [**one of**] the following:
 1. [**Liquid-filled**] [**Sealed**], bimetallic-actuated type.
 2. [**Direct**] [**Remote**]-mounted, [**metal**] [**plastic**]-case, vapor-actuated type.
 3. [**Compact**] [**Industrial**]-style, liquid-in-glass type.
 4. [**Direct**] [**Remote**]-mounted, light-activated type.
 5. Test plug with [**chlorosulfonated polyethylene synthetic**] [**EPDM**] self-sealing rubber inserts.
 - G. Thermometers at inlet and outlet of each thermal-storage tank shall be [**one of**] the following:
 1. [**Liquid-filled**] [**Sealed**], bimetallic-actuated type.
 2. [**Direct**] [**Remote**]-mounted, [**metal**] [**plastic**]-case, vapor-actuated type.
 3. [**Compact**] [**Industrial**]-style, liquid-in-glass type.
 4. [**Direct**] [**Remote**]-mounted, light-activated type.
 5. Test plug with [**chlorosulfonated polyethylene synthetic**] [**EPDM**] self-sealing rubber inserts.
 - H. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be [**one of**] the following:
 1. [**Liquid-filled**] [**Sealed**], bimetallic-actuated type.
 2. [**Direct**] [**Remote**]-mounted, [**metal**] [**plastic**]-case, vapor-actuated type.
 3. [**Compact**] [**Industrial**]-style, liquid-in-glass type.
 4. [**Direct**] [**Remote**]-mounted, light-activated type.
 - I. Thermometer stems shall be of length to match thermowell insertion length.
- 3.5 THERMOMETER SCALE-RANGE SCHEDULE:
- A. Scale Range for Chilled-Water Piping: [**Minus 40 to plus 160 deg. F**] [**Minus 40 to plus 160 deg. F and minus 40 to plus 100 deg. C**].
 - B. Scale Range for Chilled-Water Piping: [**0 to 100 deg. F**] [**0 to 100 deg. F and minus 20 to plus 50 deg. C**].
 - C. Scale Range for Chilled-Water Piping: [**0 to 150 deg. F**] [**0 to 150 deg. F and minus 20 to plus 70 deg. C**].
 - D. Scale Range for Chilled-Water Piping: [**0 to 250 deg. F**] [**0 to 250 deg. F and 0 to 150 deg. C**].

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- E. Scale Range for Condenser-Water Piping: **[0 to 100 deg. F] [0 to 100 deg. F and minus 20 to plus 50 deg. C].**
- F. Scale Range for Condenser-Water Piping: **[0 to 150 deg. F] [0 to 150 deg. F and minus 20 to plus 70 deg. C].**
- G. Scale Range for Condenser-Water Piping: **[0 to 250 deg. F] [0 to 250 deg. F and 0 to 150 deg. C].**
- H. Scale Range for Condenser-Water Piping: **[20 to 240 deg. F] [20 to 240 deg. F and 0 to 150 deg. C].**
- I. Scale Range for Condenser-Water Piping: **[30 to 240 deg. F] [30 to 240 deg. F and 0 to plus 115 deg. C].**
- J. Scale Range for Heating, Hot-Water Piping: **[0 to 250 deg. F] [0 to 250 deg. F and 0 to 150 deg. C].**
- K. Scale Range for Heating, Hot-Water Piping: **[20 to 240 deg. F] [20 to 240 deg. F and 0 to 150 deg. C].**
- L. Scale Range for Heating, Hot-Water Piping: **[30 to 240 deg. F] [30 to 240 deg. F and 0 to plus 115 deg. C].**
- M. Scale Range for Heating, Hot-Water Piping: **[50 to 400 deg. F] [50 to 400 deg. F and 0 to 200 deg. C].**
- N. Scale Range for Heating, Hot-Water Piping: **[50 to 550 deg. F] [50 to 550 deg. F and 10 to 300 deg. C].**
- O. Scale Range for Steam and Steam-Condensate Piping: **[0 to 250 deg. F] [0 to 250 deg. F and 0 to 150 deg. C].**
- P. Scale Range for Steam and Steam-Condensate Piping: **[20 to 240 deg. F] [20 to 240 deg. F and 0 to 150 deg. C].**
- Q. Scale Range for Steam and Steam-Condensate Piping: **[30 to 240 deg. F] [30 to 240 deg. F and 0 to plus 115 deg. C].**
- R. Scale Range for Steam and Steam-Condensate Piping: **[50 to 400 deg. F] [50 to 400 deg. F and 0 to 200 deg. C].**
- S. Scale Range for Air Ducts: **[Minus 40 to plus 110 deg. F] [Minus 40 to plus 110 deg. F and minus 40 to plus 45 deg. C].**
- T. Scale Range for Air Ducts: **[Minus 40 to plus 160 deg. F] [Minus 40 to plus 160 deg. F and minus 40 to plus 100 deg. C].**

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- U. Scale Range for Air Ducts: **[0 to 100 deg. F] [0 to 100 deg. F and minus 20 to plus 50 deg. C].**
- V. Scale Range for Air Ducts: **[0 to 150 deg. F] [0 to 150 deg. F and minus 20 to plus 70 deg. C].**
- W. Scale Range for Air Ducts: **[0 to 250 deg. F] [0 to 250 deg. F and 0 to 150 deg. C].**
- X. Scale Range for Air Ducts: **[20 to 240 deg. F] [20 to 240 deg. F and 0 to 150 deg. C].**
- Y. Scale Range for Air Ducts: **[30 to 240 deg. F] [30 to 240 deg. F and 0 to plus 115 deg. C].**
- Z. Scale Range for Air Ducts: **[50 to 400 deg. F] [50 to 400 deg. F and 0 to 200 deg. C].**

3.6 PRESSURE-GAGE SCHEDULE:

- A. Pressure gages at discharge of each pressure-reducing valve shall be [**one of**] the following:
 - 1. **[Liquid-filled] [Sealed] [Open-front, pressure-relief] [Solid-front, pressure-relief] <Insert type>, [direct] [remote]-mounted, metal case.**
 - 2. **[Sealed] <Insert type>, [direct] [remote]-mounted, plastic case.**
 - 3. Test plug with **[chlorosulfonated polyethylene synthetic] [EPDM]** self-sealing rubber inserts.
- B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be [**one of**] the following:
 - 1. **[Liquid-filled] [Sealed] [Open-front, pressure-relief] [Solid-front, pressure-relief] <Insert type>, [direct] [remote]-mounted, metal case.**
 - 2. **[Sealed] <Insert type>, [direct] [remote]-mounted, plastic case.**
 - 3. Test plug with **[chlorosulfonated polyethylene synthetic] [EPDM]** self-sealing rubber inserts.
- C. Pressure gages at suction and discharge of each pump shall be [**one of**] the following:
 - 1. **[Liquid-filled] [Sealed] [Open-front, pressure-relief] [Solid-front, pressure-relief] <Insert type>, [direct] [remote]-mounted, metal case.**
 - 2. **[Sealed] <Insert type>, [direct] [remote]-mounted, plastic case.**
 - 3. Test plug with **[chlorosulfonated polyethylene synthetic] [EPDM]** self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE:

- A. Scale Range for Chilled-Water Piping: **[30-in. Hg to 15 psi] [30-in. Hg to 15 psi and minus 100 to 0 kPa].**

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- B. Scale Range for Chilled-Water Piping: **[0 to 30 psi] [0 to 30 psi and 0 to 240 kPa]**.
- C. Scale Range for Chilled-Water Piping: **[0 to 100 psi] [0 to 100 psi and 0 to 600 kPa]**.
- D. Scale Range for Chilled-Water Piping: **[0 to 160 psi] [0 to 160 psi and 0 to 1100 kPa]**.
- E. Scale Range for Chilled-Water Piping: **[0 to 200 psi] [0 to 200 psi and 0 to 1400 kPa]**.
- F. Scale Range for Chilled-Water Piping: **[0 to 300 psi] [0 to 300 psi and 0 to 2500 kPa]**.
- G. Scale Range for Chilled-Water Piping: **[0 to 600 psi] [0 to 600 psi and 0 to 4000 kPa]**.
- H. Scale Range for Condenser-Water Piping: **[30-in. Hg to 15 psi] [30-in. Hg to 15 psi and minus 100 to 0 kPa]**.
- I. Scale Range for Condenser-Water Piping: **[0 to 30 psi] [0 to 30 psi and 0 to 240 kPa]**.
- J. Scale Range for Condenser-Water Piping: **[0 to 100 psi] [0 to 100 psi and 0 to 600 kPa]**.
- K. Scale Range for Condenser-Water Piping: **[0 to 160 psi] [0 to 160 psi and 0 to 1100 kPa]**.
- L. Scale Range for Condenser-Water Piping: **[0 to 200 psi] [0 to 200 psi and 0 to 1400 kPa]**.
- M. Scale Range for Condenser-Water Piping: **[0 to 300 psi] [0 to 300 psi and 0 to 2500 kPa]**.
- N. Scale Range for Condenser-Water Piping: **[0 to 600 psi] [0 to 600 psi and 0 to 4000 kPa]**.
- O. Scale Range for Heating, Hot-Water Piping: **[30-in. Hg to 15 psi] [30-in. Hg to 15 psi and minus 100 to 0 kPa]**.
- P. Scale Range for Heating, Hot-Water Piping: **[0 to 30 psi] [0 to 30 psi and 0 to 240 kPa]**.
- Q. Scale Range for Heating, Hot-Water Piping: **[0 to 100 psi] [0 to 100 psi and 0 to 600 kPa]**.
- R. Scale Range for Heating, Hot-Water Piping: **[0 to 160 psi] [0 to 160 psi and 0 to 1100 kPa]**.
- S. Scale Range for Heating, Hot-Water Piping: **[0 to 200 psi] [0 to 200 psi and 0 to 1400 kPa]**.
- T. Scale Range for Heating, Hot-Water Piping: **[0 to 300 psi] [0 to 300 psi and 0 to 2500 kPa]**.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- U. Scale Range for Heating, Hot-Water Piping: **[0 to 600 psi] [0 to 600 psi and 0 to 4000 kPa]**.
- V. Scale Range for Steam Piping: **[30-in. Hg to 15 psi] [30-in. Hg to 15 psi and minus 100 to 0 kPa]**.
- W. Scale Range for Steam Piping: **[0 to 30 psi] [0 to 30 psi and 0 to 240 kPa]**.
- X. Scale Range for Steam Piping: **[0 to 100 psi] [0 to 100 psi and 0 to 600 kPa]**.
- Y. Scale Range for Steam Piping: **[0 to 160 psi] [0 to 160 psi and 0 to 1100 kPa]**.
- Z. Scale Range for Steam Piping: **[0 to 200 psi] [0 to 200 psi and 0 to 1400 kPa]**.
- AA. Scale Range for Steam Piping: **[0 to 300 psi] [0 to 300 psi and 0 to 2500 kPa]**.
- BB. Scale Range for Steam Piping: **[0 to 600 psi] [0 to 600 psi and 0 to 4000 kPa]**.

3.8 FLOWMETER SCHEDULE:

- A. Flowmeters for Chilled-Water Piping: **[Orifice] [Pitot-tube] [Turbine] [Venturi] [Vortex-shedding]** type.
- B. Flowmeters for Condenser-Water Piping: **[Orifice] [Pitot-tube] [Turbine] [Venturi] [Vortex-shedding]** type.
- C. Flowmeters for Heating, Hot-Water Piping: **[Orifice] [Pitot-tube] [Turbine] [Venturi] [Vortex-shedding]** type.
- D. Flowmeters for Steam and Steam-Condensate Piping: **[Orifice] [Turbine] [Venturi] [Vortex-shedding]** type.

3.9 THERMAL-ENERGY METER SCHEDULE:

- A. Thermal-Energy Meters for Chilled-Water Piping: **[Impeller-turbine] [Ultrasonic]** type.
- B. Thermal-Energy Meters for Condenser-Water Piping: **[Impeller-turbine] [Ultrasonic]** type.
- C. Thermal-Energy Meters for Heating, Hot-Water Piping: **[Impeller-turbine] [Ultrasonic]** type.
- D. Thermal-Energy Meters for Steam and Steam-Condensate Piping: **[Impeller-turbine] [Ultrasonic]** type.

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END OF SECTION

SECTION 23 05 23

GENERAL-DUTY VALVES FOR HVAC PIPING
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all drawings and all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Specifications:

Section 23 05 53 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

1.3 SUMMARY:

- A. Section Includes:
 - 1. Angle valves.
 - 2. Globe valves.
 - 3. Ball valves.
 - 4. Butterfly valves.
 - 5. Check valves.
 - 6. Gate valves.
 - 7. Lubricated plug valves.
 - 8. Eccentric plug valves.
 - 9. Chainwheels

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1.4 DEFINITIONS:

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. SWP: Steam working pressure.
- E. NRS: Non-rising stem.
- F. OS&Y: Outside screw and yoke.
- G. RS: Rising stem.

1.5 ACTION SUBMITTALS:

- A. Product Data: For each type of valve.

1.6 DELIVERY, STORAGE, AND HANDLING:

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set angle and globe valves closed to prevent rattling.
 - 4. Set ball valves open to minimize exposure of functional surfaces.
 - 5. Set butterfly valves closed or slightly open.
 - 6. Block check valves in either closed or open position.
 - 7. Set gate valves closed to prevent rattling.
 - 8. Set plug valves open to minimize exposure of functional surfaces.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels, operating handles or stems as lifting or rigging points.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR GLOBE VALVES:

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded-end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 4. ASME B16.18 for solder joint.
 - 5. ASME B31.1 for power piping valves.
 - 6. ASME B31.9 for building services piping valves.
- C. Refer to HVAC valve schedule articles for applications of valves.
- D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valves in Insulated Piping: With 2-inch stem extensions.

2.2 BRONZE ANGLE VALVES:

- A. Bronze Angle Valves, Class 125:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Appollo Valves.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Or Equal
 - 2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded.
 - e. Stem and Disc: [**Bronze**] [**PTFE**].
 - f. Packing: Asbestos free.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- g. Handwheel: Malleable iron [, **bronze, or aluminum**].

B. Bronze Angle Valves, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Apollo Valves.
 - c. Stockham; Crane Energy Flow Solutions.
 - d. Or Equal.
2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem and Disc: [**Bronze**] [**PTFE**].
 - f. Packing: Asbestos free.
 - g. Handwheel: Malleable iron [, **bronze, or aluminum**].

2.3 BRONZE GLOBE VALVES:

A. Bronze Globe Valves, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; Conbraco Industries, Inc.
 - b. Crane; Crane Energy Flow Solutions.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Stockham; Crane Energy Flow Solutions.
 - f. Watts; a Watts Water Technologies company.
2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded [**or solder joint**].
 - e. Stem and Disc: [**Bronze**] [**PTFE**].
 - f. Packing: Asbestos free.
 - g. Handwheel: Malleable iron [, **bronze, or aluminum**].

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

B. Bronze Globe Valves, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; Conbraco Industries, Inc.
 - b. Crane; Crane Energy Flow Solutions.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Valve Solutions, Inc.
 - f. Watts; a Watts Water Technologies company.
2. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc: [**Bronze**] [**PTFE**].
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron [, **bronze, or aluminum**].

2.4 IRON GLOBE VALVES:

A. Iron Globe Valves, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; Conbraco Industries, Inc.
 - b. Crane; Crane Energy Flow Solutions.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Stockham; Crane Energy Flow Solutions.
 - f. Watts; a Watts Water Technologies company.
2. Description:
 - a. Standard: MSS SP-85, Type I.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: Bronze.
 - f. Packing and Gasket: Asbestos free.
 - g. Operator: Handwheel or chainwheel.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

B. Iron Globe Valves, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; Conbraco Industries, Inc.
 - b. Crane; Crane Energy Flow Solutions.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Stockham; Crane Energy Flow Solutions.
 - f. Watts; a Watts Water Technologies company.
2. Description:
 - a. Standard: MSS SP-85, Type I.
 - b. CWP Rating: 500 psig.
 - c. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: Bronze.
 - f. Packing and Gasket: Asbestos free.
 - g. Operator: Handwheel or chainwheel.

2.5 GENERAL REQUIREMENTS FOR BALL VALVES:

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 1. ASME B1.20.1 for threads for threaded-end valves.
 2. ASME B16.1 for flanges on iron valves.
 3. ASME B16.5 for flanges on steel valves.
 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 5. ASME B16.18 for solder-joint connections.
 6. ASME B31.1 for power piping valves.
 7. ASME B31.9 for building services piping valves.
- C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- D. Refer to HVAC valve schedule articles for applications of valves.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

G. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 4-inch and larger.
2. Handlever: For quarter-turn valves smaller than NPS 4-inch.

H. Valves in Insulated Piping:

1. Include 2-inch stem extensions.
2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

I. Valve Bypass and Drain Connections: MSS SP-45.

2.6 BRASS BALL VALVES:

A. Brass Ball Valves, One-Piece:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-110.
 - b. CWP Rating: 400 psig.
 - c. Body Design: One piece.
 - d. Body Material: Forged brass.
 - e. Ends: Threaded.
 - f. Seats: PTFE.
 - g. Stem: Brass.
 - h. Ball: Chrome-plated brass.
 - i. Port: Reduced.

B. Brass Ball Valves, Two-Piece with Full Port and Brass Trim:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Forged brass.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Brass.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- i. Ball: Chrome-plated brass.
- j. Port: Full.

C. Brass Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Forged brass.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Stainless steel.
 - i. Ball: Stainless steel, vented.
 - j. Port: Full.

D. Brass Ball Valves, Two-Piece with Regular Port and Brass Trim:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Forged brass.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Brass.
 - i. Ball: Chrome-plated brass.
 - j. Port: Regular.

E. Brass Ball Valves, Two-Piece with Regular Port and Stainless-Steel Trim:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Brass or bronze.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- f. Ends: Threaded.
- g. Seats: PTFE.
- h. Stem: Stainless steel.
- i. Ball: Stainless steel, vented.
- j. Port: Regular.

F. Brass Ball Valves, Three-Piece with Full Port and Brass Trim:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Three piece.
 - e. Body Material: Forged brass.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Brass.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.

G. Brass Ball Valves, Three-Piece with Full Port and Stainless-Steel Trim:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Three piece.
 - e. Body Material: Forged brass.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Stainless steel.
 - i. Ball: Stainless steel, vented.
 - j. Port: Full.

2.7 BRONZE BALL VALVES:

A. Bronze Ball Valves, One-Piece with Bronze Trim:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Standard: MSS SP-110.
- b. CWP Rating: 400 psig.
- c. Body Design: One piece.
- d. Body Material: Bronze.
- e. Ends: Threaded.
- f. Seats: PTFE.
- g. Stem: Bronze.
- h. Ball: Chrome-plated brass.
- i. Port: Reduced.

B. Bronze Ball Valves, One-Piece with Stainless-Steel Trim:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-110.
 - b. CWP Rating: 600 psig.
 - c. Body Design: One piece.
 - d. Body Material: Bronze.
 - e. Ends: Threaded.
 - f. Seats: PTFE.
 - g. Stem: Stainless steel.
 - h. Ball: Stainless steel, vented.
 - i. Port: Reduced.

C. Bronze Ball Valves, Two-Piece with Full Port and Bronze or Brass Trim:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Bronze.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.

D. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Standard: MSS SP-110.
- b. SWP Rating: 150 psig.
- c. CWP Rating: 600 psig.
- d. Body Design: Two piece.
- e. Body Material: Bronze.
- f. Ends: Threaded.
- g. Seats: PTFE.
- h. Stem: Stainless steel.
- i. Ball: Stainless steel, vented.
- j. Port: Full.

E. Bronze Ball Valves, Two-Piece with Regular Port and Bronze or Brass Trim:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Bronze.
 - i. Ball: Chrome-plated brass.
 - j. Port: Regular.

F. Bronze Ball Valves, Two-Piece with Regular Port and Stainless-Steel Trim:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Stainless steel.
 - i. Ball: Stainless steel, vented.
 - j. Port: Regular.

G. Bronze Ball Valves, Three-Piece with Full Port and Bronze or Brass Trim:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Three piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Bronze.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.

H. Bronze Ball Valves, Three-Piece with Full Port Stainless-Steel Trim:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Three piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Stainless steel.
 - i. Ball: Stainless steel, vented.
 - j. Port: Full.

I. Bronze Ball Valves, Three-Piece with Regular Port, and Stainless-Steel Trim:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Three piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded and solder.
 - g. Seats: PTFE.
 - h. Stem: Stainless steel.
 - i. Ball: Stainless steel, vented.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

j. Port: Regular.

2.8 STEEL BALL VALVES:

A. Steel Ball Valves with Full Port and Stainless-Steel Trim, Class 150:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-72.
 - b. CWP Rating: 285 psig.
 - c. Body Design: Split body.
 - d. Body Material: Carbon steel, ASTM A 216, Type WCB.
 - e. Ends: Flanged.
 - f. Seats: PTFE.
 - g. Stem: Stainless steel.
 - h. Ball: Stainless steel, vented.
 - i. Port: Full.

B. Steel Ball Valves with Full Port and Stainless-Steel Trim, Class 300:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-72.
 - b. CWP Rating: 720 psig.
 - c. Body Design: Split body.
 - d. Body Material: Carbon steel, ASTM A 216, Type WCB.
 - e. Ends: Flanged.
 - f. Seats: PTFE.
 - g. Stem: Stainless steel.
 - h. Ball: Stainless steel, vented.
 - i. Port: Full.

2.9 IRON BALL VALVES:

A. Iron Ball Valves, Class 125:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-72.
 - b. CWP Rating: 200 psig.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- c. Body Design: Split body.
- d. Body Material: ASTM A 126, gray iron.
- e. Ends: Flanged.
- f. Seats: PTFE.
- g. Stem: Stainless steel.
- h. Ball: Stainless steel.
- i. Port: Full.

2.10 GENERAL REQUIREMENTS FOR BUTTERFLY VALVES:

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B16.1 for flanges on iron valves.
 - 2. ASME B16.5 for pipe flanges and flanged fittings, NPS 1/2 through NPS 24.
 - 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 4. ASME B31.1 for power piping valves.
 - 5. ASME B31.9 for building services piping valves.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valve Actuator Types:
 - 1. Gear Actuator: For valves NPS 8 and larger.
 - 2. Handlever: For valves NPS 6 and smaller.
 - 3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.
- G. Valves in Insulated Piping: With 2-inch stem extensions with extended necks.

2.11 IRON, SINGLE-FLANGE BUTTERFLY VALVES:

- A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Description:
 - a. Standard: MSS SP-67, Type I.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- b. CWP Rating: [**150 psig**] [**200 psig**].
- c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
- d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
- e. Seat: [**EPDM**] [**NBR**].
- f. Stem: One- or two-piece stainless steel.
- g. Disc: Aluminum bronze.

B. Iron, Single-Flange Butterfly Valves with Ductile-Iron Disc:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. CWP Rating: [**150 psig**] [**200 psig**].
 - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - e. Seat: [**EPDM**] [**NBR**].
 - f. Stem: One- or two-piece stainless steel.
 - g. Disc: Nickel-plated [**or -coated**] ductile iron.

C. Iron, Single-Flange Butterfly Valves with Stainless-Steel Disc:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. CWP Rating: [**150 psig**] [**200 psig**].
 - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - e. Seat: [**EPDM**] [**NBR**].
 - f. Stem: One- or two-piece stainless steel.
 - g. Disc: Stainless steel.

2.12 DUCTILE-IRON, GROOVED-END BUTTERFLY VALVES:

A. Iron, Grooved-End Butterfly Valves, 175 CWP:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-67, Type I.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- b. CWP Rating: 175 psig.
- c. Body Material: Coated, ductile iron.
- d. Stem: Two-piece stainless steel.
- e. Disc: Coated, ductile iron.
- f. Seal: EPDM.

B. Iron, Grooved-End Butterfly Valves, 300 CWP:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. NPS 8 and Smaller CWP Rating: 300 psig.
 - c. NPS 10 and Larger CWP Rating: 200 psig.
 - d. Body Material: Coated, ductile iron.
 - e. Stem: Two-piece stainless steel.
 - f. Disc: Coated, ductile iron.
 - g. Seal: EPDM.

2.13 HIGH-PERFORMANCE BUTTERFLY VALVES:

A. Single-Flange, High-Performance Butterfly Valves, Class 150:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-68.
 - b. CWP Rating: 285 psig at 100 deg. F.
 - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
 - e. Seat: Reinforced PTFE or metal.
 - f. Stem: Stainless steel; offset from seat plane.
 - g. Disc: Carbon steel.
 - h. Service: Bidirectional.

B. Single-Flange, High-Performance Butterfly Valves, Class 300:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-68.
 - b. CWP Rating: 720 psig at 100 deg. F.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
- d. Body Material: Carbon steel, cast iron, or ductile iron.
- e. Seat: Reinforced PTFE or metal.
- f. Stem: Stainless steel; offset from seat plane.
- g. Disc: Carbon steel.
- h. Service: Bidirectional.

2.14 GENERAL REQUIREMENTS FOR CHECK VALVES:

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded-end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 4. ASME B16.18 for solder joint.
 - 5. ASME B31.1 for power piping valves.
 - 6. ASME B31.9 for building services piping valves.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Bypass and Drain Connections: MSS SP-45.

2.15 BRONZE LIFT CHECK VALVES:

- A. Bronze Lift Check Valves with Bronze Disc, Class 125:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Vertical flow.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- d. Body Material: ASTM B 61 or ASTM B 62, bronze.
- e. Ends: Threaded.
- f. Disc: Bronze.

B. Bronze Lift Check Valves with Nonmetallic Disc, Class 125:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Vertical flow.
 - d. Body Material: ASTM B 61 or ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: NBR or PTFE.

2.16 BRONZE SWING CHECK VALVES:

A. Bronze Swing Check Valves with Bronze Disc, Class 125:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: Bronze.

B. Bronze Swing Check Valves with Nonmetallic Disc, Class 125:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-80, Type 4.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: PTFE.

C. Bronze Swing Check Valves with Bronze Disc, Class 150:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 300 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: Bronze.

D. Bronze Swing Check Valves with Nonmetallic Disc, Class 150:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-80, Type 4.
 - b. CWP Rating: 300 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: PTFE.

2.17 IRON SWING CHECK VALVES:

A. Iron Swing Check Valves with Metal Seats, Class 125:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Design: Clear or full waterway.
 - e. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - f. Ends: Flanged.
 - g. Trim: Bronze.
 - h. Gasket: Asbestos free.

B. Iron Swing Check Valves with Nonmetallic-to-Metal Seats, Class 125:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Standard: MSS SP-71, Type I.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
- c. NPS 14 to NPS 24, CWP Rating: 150 psig.
- d. Body Design: Clear or full waterway.
- e. Body Material: ASTM A 126, gray iron with bolted bonnet.
- f. Ends: Flanged.
- g. Trim: Composition.
- h. Seat Ring: Bronze.
- i. Disc Holder: Bronze.
- j. Disc: PTFE.
- k. Gasket: Asbestos free.

C. Iron Swing Check Valves with Metal Seats, Class 250:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 300 psig.
 - d. Body Design: Clear or full waterway.
 - e. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - f. Ends: Flanged.
 - g. Trim: Bronze.
 - h. Gasket: Asbestos free.

2.18 IRON SWING CHECK VALVES WITH CLOSURE CONTROL:

A. Iron Swing Check Valves with Lever- and Spring-Closure Control, Class 125:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Design: Clear or full waterway.
 - e. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - f. Ends: Flanged.
 - g. Trim: Bronze.
 - h. Gasket: Asbestos free.
 - i. Closure Control: Factory-installed, exterior lever and spring.

B. Iron Swing Check Valves with Lever and Weight-Closure Control, Class 125:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Design: Clear or full waterway.
 - e. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - f. Ends: Flanged.
 - g. Trim: Bronze.
 - h. Gasket: Asbestos free.
 - i. Closure Control: Factory-installed, exterior lever and weight.

2.19 IRON, GROOVED-END SWING CHECK VALVES:

A. Iron, Grooved-End Swing Check Valves, 300 CWP:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. CWP Rating: 300 psig.
 - b. Body Material: ASTM A 536, ductile iron.
 - c. Seal: EPDM.
 - d. Disc: Spring operated, ductile iron or stainless steel.

2.20 IRON, CENTER-GUIDED CHECK VALVES:

A. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 125:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Material: ASTM A 126, gray iron.
 - e. Style: Compact wafer.
 - f. Seat: Bronze.

B. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 125:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Description:

- a. Standard: MSS SP-125.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
- c. NPS 14 to NPS 24, CWP Rating: 150 psig.
- d. Body Material: ASTM A 126, gray iron.
- e. Style: Globe, spring loaded.
- f. Ends: Flanged.
- g. Seat: Bronze.

C. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 150:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2. Description:

- a. Standard: MSS SP-125.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
- c. NPS 14 to NPS 24, CWP Rating: 250 psig.
- d. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
- e. Style: Compact wafer.
- f. Seat: Bronze.

D. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 150:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2. Description:

- a. Standard: MSS SP-125.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
- c. NPS 14 to NPS 24, CWP Rating: 250 psig.
- d. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
- e. Style: Globe, spring loaded.
- f. Ends: Flanged.
- g. Seat: Bronze.

E. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 250:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2. Description:

- a. Standard: MSS SP-125.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
- c. NPS 14 to NPS 24, CWP Rating: 300 psig.
- d. Body Material: ASTM A 126, gray iron.
- e. Style: Compact wafer, spring loaded.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

f. Seat: Bronze.

F. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 250:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 300 psig.
 - d. Body Material: ASTM A 126, gray iron.
 - e. Style: Globe, spring loaded.
 - f. Ends: Flanged.
 - g. Seat: Bronze.

G. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 300:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 400 psig.
 - d. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - e. Style: Compact wafer, spring loaded.
 - f. Seat: Bronze.

H. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 300:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 400 psig.
 - d. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - e. Style: Globe, spring loaded.
 - f. Ends: Flanged.
 - g. Seat: Bronze.

I. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 125:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Standard: MSS SP-125.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
- c. NPS 14 to NPS 24, CWP Rating: 150 psig.
- d. Body Material: ASTM A 126, gray iron.
- e. Style: Compact wafer.
- f. Seat: [EPDM] [or] [NBR] <Insert material>.

J. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 125:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Material: ASTM A 126, gray iron.
 - e. Style: Globe, spring loaded.
 - f. Ends: Flanged.
 - g. Seat: [EPDM] [or] [NBR] <Insert material>.

K. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 150:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 250 psig.
 - d. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - e. Style: Compact wafer.
 - f. Seat: [EPDM] [or] [NBR] <Insert material>.

L. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 150:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 250 psig.
 - d. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - e. Style: Globe, spring loaded.
 - f. Ends: Flanged.
 - g. Seat: [EPDM] [or] [NBR] <Insert material>.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

M. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 250:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 300 psig.
 - d. Body Material: ASTM A 126, gray iron.
 - e. Style: Compact wafer, spring loaded.
 - f. Seat: [EPDM] [or] [NBR] <Insert material>.

N. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 250:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 300 psig.
 - d. Body Material: ASTM A 126, gray iron.
 - e. Style: Globe, spring loaded.
 - f. Ends: Flanged.
 - g. Seat: [EPDM] [or] [NBR] <Insert material>.

O. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 300:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 400 psig.
 - d. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - e. Style: Compact wafer, spring loaded.
 - f. Seat: [EPDM] [or] [NBR] <Insert material>.

P. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 300:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- c. NPS 14 to NPS 24, CWP Rating: 400 psig.
- d. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
- e. Style: Globe, spring loaded.
- f. Ends: Flanged.
- g. Seat: [EPDM] [or] [NBR] <Insert material>.

2.21 IRON, PLATE-TYPE CHECK VALVES:

A. Iron, Dual-Plate Check Valves with Metal Seat, Class 125:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: API 594.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Design: Wafer, spring-loaded plates.
 - e. Body Material: ASTM A 126, gray iron.
 - f. Seat: Bronze.

B. Iron, Dual-Plate Check Valves with Metal Seat, Class 150:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: API 594.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 250 psig.
 - d. Body Design: Wafer, spring-loaded plates.
 - e. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - f. Seat: Bronze.

C. Iron, Dual-Plate Check Valves with Metal Seat, Class 250:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: API 594.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 300 psig.
 - d. Body Design: Wafer, spring-loaded plates.
 - e. Body Material: ASTM A 126, gray iron.
 - f. Seat: Bronze.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

D. Iron, Dual-Plate Check Valves with Metal Seat, Class 300:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: API 594.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 400 psig.
 - d. Body Design: Wafer, spring-loaded plates.
 - e. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - f. Seat: Bronze.

E. Iron, Single-Plate Check Valves with Resilient Seat, Class 125:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: API 594.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Design: Wafer, spring-loaded plate.
 - e. Body Material: ASTM A 126, gray iron.
 - f. Seat: [EPDM] [or] [NBR] <Insert material>.

F. Iron, Dual-Plate Check Valves with Resilient Seat, Class 125:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: API 594.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Design: Wafer, spring-loaded plates.
 - e. Body Material: ASTM A 126, gray iron.
 - f. Seat: [EPDM] [or] [NBR] <Insert material>.

G. Iron, Dual-Plate Check Valves with Resilient Seat, Class 150:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: API 594.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 250 psig.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- d. Body Design: Wafer, spring-loaded plates.
- e. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
- f. Seat: [EPDM] [or] [NBR] <Insert material>.

H. Iron, Wafer, Single-Plate Check Valves with Resilient Seat, Class 250:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: API 594.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 300 psig.
 - d. Body Design: Wafer, spring-loaded plate.
 - e. Body Material: ASTM A 126, gray iron.
 - f. Seat: [EPDM] [or] [NBR] <Insert material>.

I. Iron, Dual-Plate Check Valves with Resilient Seat, Class 250:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: API 594.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 300 psig.
 - d. Body Design: Wafer, spring-loaded plates.
 - e. Body Material: ASTM A 126, gray iron.
 - f. Seat: [EPDM] [or] [NBR] <Insert material>.

J. Iron, Dual-Plate Check Valves with Resilient Seat, Class 300:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: API 594.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 400 psig.
 - d. Body Design: Wafer, spring-loaded plates.
 - e. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - f. Seat: [EPDM] [or] [NBR] <Insert material>.

2.22 GENERAL REQUIREMENTS FOR GATE VALVES:

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.1 for power piping valves.
6. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. RS Valves in Insulated Piping: With 2-inch stem extensions.

H. Valve Bypass and Drain Connections: MSS SP-45.

2.23 BRONZE GATE VALVES:

A. Bronze Gate Valves, NRS, Class 125:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded [**or solder joint**].
 - e. Stem: Bronze.
 - f. Disc: Solid wedge; bronze.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron [, **bronze, or aluminum**].

B. Bronze Gate Valves, RS, Class 125:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Standard: MSS SP-80, Type 2.
- b. CWP Rating: 200 psig.
- c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
- d. Ends: Threaded [**or solder joint**].
- e. Stem: Bronze.
- f. Disc: Solid wedge; bronze.
- g. Packing: Asbestos free.
- h. Handwheel: Malleable iron, bronze, or aluminum.

C. Bronze Gate Valves, NRS, Class 150:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc: Solid wedge; bronze.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron, bronze, or aluminum.

D. Bronze Gate Valves, RS, Class 150:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc: Solid wedge; bronze.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron [, **bronze, or aluminum**].

2.24 IRON GATE VALVES:

A. Iron Gate Valves, NRS, Class 125:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Description:

- a. Standard: MSS SP-70, Type I.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
- c. NPS 14 to NPS 24, CWP Rating: 150 psig.
- d. Body Material: ASTM A 126, gray iron with bolted bonnet.
- e. Ends: Flanged.
- f. Trim: Bronze.
- g. Disc: Solid wedge.
- h. Packing and Gasket: Asbestos free.

B. Iron Gate Valves, OS&Y, Class 125:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2. Description:

- a. Standard: MSS SP-70, Type I.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
- c. NPS 14 to NPS 24, CWP Rating: 150 psig.
- d. Body Material: ASTM A 126, gray iron with bolted bonnet.
- e. Ends: Flanged.
- f. Trim: Bronze.
- g. Disc: Solid wedge.
- h. Packing and Gasket: Asbestos free.

C. Iron Gate Valves, NRS, Class 250:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2. Description:

- a. Standard: MSS SP-70, Type I.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
- c. NPS 14 to NPS 24, CWP Rating: 300 psig.
- d. Body Material: ASTM A 126, gray iron with bolted bonnet.
- e. Ends: Flanged.
- f. Trim: Bronze.
- g. Disc: Solid wedge.
- h. Packing and Gasket: Asbestos free.

D. Iron Gate Valves, OS&Y, Class 250:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2. Description:

- a. Standard: MSS SP-70, Type I.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
- c. NPS 14 to NPS 24, CWP Rating: 300 psig.
- d. Body Material: ASTM A 126, gray iron with bolted bonnet.
- e. Ends: Flanged.
- f. Trim: Bronze.
- g. Disc: Solid wedge.
- h. Packing and Gasket: Asbestos free.

2.25 CHAINWHEELS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Valve actuation assembly with sprocket rim, chain guides, chain [, **and attachment brackets for mounting chainwheels directly to hand wheels**].
 - 1. Sprocket Rim with Chain Guides: [**Ductile iron**] [**Ductile or cast iron**] [**Cast iron**] [**Aluminum**] [**Bronze**], of type and size required for valve. [**Include zinc or epoxy coating.**]
 - 2. Chain: [**Hot-dip-galvanized steel**] [**Brass**] [**Stainless steel**], of size required to fit sprocket rim.

2.26 GENERAL REQUIREMENTS FOR PLUG VALVES:

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded-end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 4. ASME B31.1 for power piping valves.
 - 5. ASME B31.9 for building services piping valves.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valve Actuator Types: Wrench. Furnish Owner with one wrench for every [**five**] [**10**] **<Insert number>** plug valves, for each size square plug-valve head.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.27 LUBRICATED PLUG VALVES:

A. Class 125, Lubricated Plug Valves with Threaded Ends:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-78, Type I single gland.
 - b. NPS 2-1/2 to NPS 4, CWP Rating: 200 psig.
 - c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - d. Pattern: [**Regular**] [**or**] [**short**] [**venturi**].
 - e. Plug: Cast iron or bronze with sealant groove.

B. Class 125, Lubricated Plug Valves with Flanged Ends:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-78, [**Type I single gland**] [**or**] [**Type II regular gland**].
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - e. Pattern: [**Regular**] [**or**] [**short**] [**venturi**].
 - f. Plug: Cast iron or bronze with sealant groove.

C. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: MSS SP-78, Type IV.
 - b. NPS 2-1/2 to NPS 4, CWP Rating: 200 psig.
 - c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - d. Pattern: [**Regular**] [**or**] [**short**] [**venturi**].
 - e. Plug: Cast iron or bronze with sealant groove.

D. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Description:
 - a. Standard: MSS SP-78, Type IV.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - d. Pattern: [**Regular**] [**or**] [**short**] [**venturi**].
 - e. Plug: Cast iron or bronze with sealant groove.
- E. Class 250, Lubricated Plug Valves with Threaded Ends:
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Description:
 - a. Standard: MSS SP-78, [**Type I single gland**] [**or**] [**Type II regular gland**].
 - b. NPS 2-1/2 to NPS 4, CWP Rating: 400 psig.
 - c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - d. Pattern: [**Regular**] [**or**] [**short**] [**venturi**].
 - e. Plug: Cast iron or bronze with sealant groove.
- F. Class 250, Lubricated Plug Valves with Flanged Ends:
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Description:
 - a. Standard: MSS SP-78, [**Type I single gland**] [**or**] [**Type II regular gland**].
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 300 psig.
 - d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
 - e. Pattern: [**Regular**] [**or**] [**short**] [**venturi**].
 - f. Plug: Cast iron or bronze with sealant groove.
- G. Class 250, Cylindrical, Lubricated Plug Valves with Threaded Ends:
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Description:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Standard: MSS SP-78, Type IV.
- b. NPS 2-1/2 to NPS 4, CWP Rating: 400 psig.
- c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
- d. Pattern: [**Regular**] [**or**] [**short**] [**venturi**].
- e. Plug: Cast iron or bronze with sealant groove.

H. Class 250, Cylindrical, Lubricated Plug Valves with Flanged Ends:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-78, Type IV.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
 - c. Body Material: ASTM A 48/A 48M or ASTM A 126, Grade 40 cast iron with lubrication-sealing system.
 - d. Pattern: [**Regular**] [**or**] [**short**] [**venturi**].
 - e. Plug: Cast iron or bronze with sealant groove.

2.28 ECCENTRIC PLUG VALVES:

A. 175 CWP, Eccentric Plug Valves with Resilient Seating.

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Description:
 - a. Standard: MSS SP-108.
 - b. CWP Rating: 175 psig minimum.
 - c. Body and Plug: ASTM A 48/A 48M, gray iron; ASTM A 126, gray iron; or ASTM A 536, ductile iron.
 - d. Bearings: Oil-impregnated bronze or stainless steel.
 - e. Ends: Flanged.
 - f. Stem-Seal Packing: Asbestos free.
 - g. Plug, Resilient-Seating Material: Suitable for potable-water service unless otherwise indicated.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION:

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for globe valves [NPS 4] <Insert pipe size> and larger and more than [96-inches] <Insert dimension> above floor. Extend chains to [60-inches] <Insert dimension> above finished floor.
- F. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. [Center-Guided] [and] [Plate-Type] Check Valves: In horizontal or vertical position, between flanges.
 - 3. Lift Check Valves: With stem, upright and plumb.
- G. Install valve tags. Comply with requirements in Section 23 05 53 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT for valve tags and schedules.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3.3 ADJUSTING:

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR GLOBE VALVE APPLICATIONS:

- A. If valve applications are not indicated, use the following:
 - 1. Throttling Service except Steam: **[Globe]** **[Globe or angle]** valves.
 - 2. Throttling Service, Steam: **[Globe]** **[Globe or angle]** valves.
- B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- C. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.5 CHILLED-WATER VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, **[Class 125]** **[Class 150]**, **[bronze]** **[PTFE]** disc, with **[soldered]** **[threaded]** ends.
- B. Pipe NPS 2-1/2 and Larger: Iron globe valves, **[Class 125]** **[Class 250]**, with flanged ends.

3.6 CONDENSER-WATER VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, **[Class 125]** **[Class 150]**, with **[bronze]** **[PTFE]** disc and **[soldered]** **[threaded]** ends.
- B. Pipe NPS 2-1/2 and Larger: Iron globe valves, **[Class 125]** **[Class 250]**, with flanged ends.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3.7 HEATING-WATER VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, [Class 125] [Class 150], with [bronze] [PTFE] disc, and [soldered] [threaded] ends.
- B. Pipe NPS 2-1/2 and Larger: Iron globe valves, [Class 125] [Class 250], with flanged ends.

3.8 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS):

- A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, [Class 125] [Class 150], [bronze] [PTFE] disc, and [soldered] [threaded] ends.
- B. Pipe NPS 2-1/2 and Larger: Iron globe valves, [Class 125] [Class 250], with flanged ends.

3.9 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG):

- A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, [Class 125] [Class 150], with [bronze] [PTFE] disc and [soldered] [threaded] ends.
- B. Pipe Sizes NPS 2-1/2 and Larger: Iron globe valves, [Class 125] [Class 250].

3.10 STEAM-CONDENSATE VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, [Class 125] [Class 150], with [bronze] [PTFE] disc, and with [soldered] [threaded] ends.
- B. Pipe NPS 2-1/2 and Larger: Iron globe valves, [Class 125] [Class 250].

3.11 GENERAL REQUIREMENTS FOR BALL VALVE APPLICATIONS:

- A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.12 CHILLED-WATER VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: [**Brass**] [**or**] [**bronze**] ball valves, [**one**] [**two**] [**three**] piece, with [**brass**] [**bronze**] [**stainless-steel**] trim, and [**full**] [**regular**] [**reduced**] port.
 1. Valves may be provided with solder-joint ends instead of threaded ends.
- B. Pipe NPS 2-1/2 and Larger:
 1. Iron ball valves, Class 125.
 - a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
 2. Steel ball valves, Class 150.

3.13 CONDENSER-WATER VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: [**Brass**] [**or**] [**bronze**] ball valves, [**one**] [**two**] [**three**] piece with [**brass**] [**bronze**] [**stainless-steel**] trim, and [**full**] [**regular**] [**reduced**] port.
 1. Valves may be provided with solder-joint ends instead of threaded ends.
- B. Pipe NPS 2-1/2 and Larger:
 1. Iron ball valves, Class 125.
 - a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
 2. Steel ball valves, Class 150.

3.14 HEATING-WATER VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: [**Brass**] [**or**] [**bronze**] ball valves, [**one**] [**two**] [**three**] piece with [**brass**] [**bronze**] [**stainless-steel**] trim, and [**full**] [**regular**] [**reduced**] port.
 1. Valves may be provided with solder-joint ends instead of threaded ends.
- B. Pipe NPS 2-1/2 and Larger:
 1. Iron ball valves, Class 125.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Steel ball valves, Class 150.

3.15 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS):

- A. Pipe NPS 2 and Smaller: [**Brass**] [**or**] [**bronze**] ball valves, [**one**] [**two**] [**three**] piece, with [**brass**] [**bronze**] [**stainless-steel**] trim, and [**full**] [**regular**] [**reduced**] port.
- B. Pipe NPS 2-1/2 and Larger:
 1. Iron ball valves, Class 125.
 - a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
 2. Steel ball valves, Class 150.

3.16 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG):

- A. Pipe NPS 2 and Smaller: [**Brass**] [**or**] [**bronze**] ball valves, [**one**] [**two**] [**three**] piece with [**brass**] [**bronze**] [**stainless-steel**] trim, and [**full**] [**regular**] [**reduced**] port.
- B. Pipe NPS 2-1/2 and Larger:
 1. Iron ball valves, Class 125.
 - a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
 2. Steel ball valves, Class 300.

3.17 STEAM-CONDENSATE VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: [**Brass**] [**or**] [**bronze**] ball valves, [**one**] [**two**] [**three**] piece with [**brass**] [**bronze**] [**stainless-steel**] trim, and [**full**] [**regular**] [**reduced**] port.
- B. Pipe NPS 2-1/2 and Larger:
 1. Iron ball valves, Class 125.
 - a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
 2. Steel ball valves, Class 300.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3.18 CHILLED-WATER BUTTERFLY VALVE SCHEDULE:

A. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: [**Aluminum-bronze**] [**Ductile-iron**] [**Stainless-steel**] disc, 200 CWP, and [**EPDM**] [**NBR**] seat.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: [**Aluminum-bronze**] [**Ductile-iron**] [**Stainless-steel**] disc, 150 CWP, and [**EPDM**] [**NBR**] seat.
3. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: [**175**] [**300**] CWP.
4. High-Performance Butterfly Valves: Single flange, [**Class 150**] [**Class 300**].

3.19 CONDENSER-WATER BUTTERFLY VALVE SCHEDULE:

A. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: [**Aluminum-bronze**] [**Ductile-iron**] [**Stainless-steel**] disc, 200 CWP, and [**EPDM**] [**NBR**] seat.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: [**Aluminum-bronze**] [**Ductile-iron**] [**Stainless-steel**] disc, 150 CWP, and [**EPDM**] [**NBR**] seat.
3. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: [**175**] [**300**] CWP.
4. High-Performance Butterfly Valves: Single flange, [**Class 150**] [**Class 300**].

3.20 HEATING-WATER BUTTERFLY VALVE SCHEDULE:

A. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: [**Aluminum-bronze**] [**Ductile-iron**] [**Stainless-steel**] disc, 200 CWP, and [**EPDM**] [**NBR**] seat.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: [**Aluminum-bronze**] [**Ductile-iron**] [**Stainless-steel**] disc, 150 CWP, and [**EPDM**] [**NBR**] seat.
3. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: [**175**] [**300**] CWP.
4. High-Performance Butterfly Valves: Single flange, [**Class 150**] [**Class 300**].

3.21 LOW-PRESSURE STEAM BUTTERFLY VALVE SCHEDULE (15 PSIG OR LESS):

- A. Pipe NPS 2-1/2 and Larger: High-performance butterfly valves, single flange, [**Class 150**] [**Class 300**].

3.22 HIGH-PRESSURE STEAM BUTTERFLY VALVE SCHEDULE (MORE THAN 15 PSIG):

- A. Pipe NPS 2-1/2 and Larger: High-performance butterfly valves, single flange, [**Class 150**] [**Class 300**].

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3.23 STEAM-CONDENSATE BUTTERFLY VALVE SCHEDULE:

- A. Pipe NPS 2-1/2 and Larger: High-performance butterfly valves, single flange, [Class 150] [Class 300].

3.24 GENERAL REQUIREMENTS FOR GATE VALVE APPLICATIONS:

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Gate valves.
- B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves, except wafer types, with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends, except where solder-joint valve-end option is indicated in valve schedules below.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
 - 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
 - 6. For Steel Piping, NPS 5 and Larger: Flanged ends.
 - 7. For Grooved-End [Copper Tubing] [and] [Steel Piping], except for Steam and Steam Condensate Piping: Valve ends may be grooved.

3.25 CHILLED-WATER VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: Bronze valves, [NRS] [RS], [Class 125] [Class 150], with [soldered] [threaded] ends.
- B. Pipe NPS 2-1/2 and Larger: Iron gate valves, [NRS] [OS&Y], [Class 125] [Class 250].

3.26 CONDENSER-WATER VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: Bronze valves, [NRS] [RS], [Class 125] [Class 150], with [soldered] [threaded] ends.
- B. Pipe NPS 2-1/2 and Larger: Iron gate valves, [NRS] [OS&Y], [Class 125] [Class 250].

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3.27 HEATING-WATER VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: Bronze valves, [NRS] [RS], [Class 125] [Class 150] with [soldered] [threaded] ends.
- B. Pipe NPS 2-1/2 and Larger: Iron gate valves, [NRS] [OS&Y], [Class 125] [Class 250].

3.28 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS):

- A. Pipe NPS 2 and Smaller: Bronze gate valves, [NRS] [RS], [Class 125] [Class 150].
- B. Pipe NPS 2-1/2 and Larger: Iron gate valves, [NRS] [OS&Y], [Class 125] [Class 250].

3.29 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG):

- A. Pipe NPS 2 and Smaller: Bronze gate valves, [NRS] [RS], [Class 125] [Class 150].
- B. Pipe NPS 2-1/2 and Larger: Iron gate valves, [NRS] [OS&Y], [Class 125] [Class 250].

3.30 STEAM-CONDENSATE VALVE SCHEDULE:

- A. Pipe NPS 2 and Smaller: Bronze gate valves, [NRS] [RS], [Class 125] [Class 150].
- B. Pipe NPS 2-1/2 and Larger: Iron gate valves, [NRS] [OS&Y], [Class 125] [Class 250].

3.31 GENERAL REQUIREMENTS FOR PLUG VALVE APPLICATIONS:

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Plug valves.
- B. If valves with CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- C. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 6. For Steel Piping, NPS 5 and Larger: Flanged ends.

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7. For Grooved-End [**Copper Tubing**] [**and**] [**Steel Piping**] except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.32 HOT-WATER AND CHILLED-WATER VALVE SCHEDULE:

A. Pipe NPS 2-1/2 and Larger:

1. Lubricated Plug Valves: [**Class 125**] [**Class 250**], [**regular gland**] [**cylindrical**], [**threaded**] [**flanged**].
2. Eccentric Plug Valves: 175 CWP, resilient seating.

3.33 CONDENSER-WATER VALVE SCHEDULE:

A. Pipe NPS 2-1/2 and Larger: Lubricated plug valves, [**Class 125**] [**Class 250**], [**regular gland**] [**cylindrical**], [**threaded**] [**flanged**].

3.34 STEAM-CONDENSATE VALVE SCHEDULE:

A. Pipe NPS 2-1/2 and Larger: Lubricated plug valves, [**Class 125**] [**Class 250**], [**regular gland**] [**cylindrical**], [**threaded**] [**flanged**].

END OF SECTION

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

Valve Service	NPS	Globe Valve Description	Ball Valve Description	Butterfly Valve Description	Gate Valve Description	Plug Valve Description
Chilled-Water Valves	2 and smaller	Bronze angle or globe valves, Class 125 Class 150, bronze PTFE disc, with 250, with flanged ends	Brass or bronze ball valves, one two three piece, with brass bronze stainless steel	-	Bronze valves, NPS RS, Class 125 Class 150, With	-
	2-1/2 and larger	Iron Globe Valves, Class 125 Class 250, with flanged ends	Iron ball valves, Class 125 / Steel ball valves, Class 150	1.) Iron single-flange butterfly valves, NPS 2-1/2 to 12: Aluminum-bronze Ductile-iron Stainless steel disc, 200 CWP, and EPDM NBR seat 2.) Iron single-flange butterfly valves, NPS 14 to 24: Aluminum-bronze Ductile-iron Stainless steel disc, 150 CWP, and EPDM NBR seat 3.) Iron, Grooved-End butterfly valves, NPS 2-1/2 to 12: 175 300 CWP 4.) High performance butterfly valves: Single flange, Class 150 Class 300	Iron gate valves, NPS OS&Y, Class 125 Class 250	1.) Lubricated plug Valves: Class 125 Class 250, regular gland cylindrical, threaded flanged 2.) Eccentric plug valves: 175 CWP, resilient seating
	2 and smaller	Bronze angle or globe valves, Class 125 Class 150, bronze PTFE disc, with 250, with flanged ends	Brass or bronze ball valves, one two three piece, with brass bronze stainless steel	-	Bronze valves, NPS RS, Class 125 Class 150, With	-
	2-1/2 and larger	Iron Globe Valves, Class 125 Class 250, with flanged ends	Iron ball valves, Class 125 / Steel ball valves, Class 150	1.) Iron single-flange butterfly valves, NPS 2-1/2 to 12: Aluminum-bronze Ductile-iron Stainless steel disc, 200 CWP, and EPDM NBR seat 2.) Iron single-flange butterfly valves, NPS 14 to 24: Aluminum-bronze Ductile-iron Stainless steel disc, 150 CWP, and EPDM NBR seat 3.) Iron, Grooved-End butterfly valves, NPS 2-1/2 to 12: 175 300 CWP 4.) High performance butterfly valves: Single flange, Class 150 Class 300	Iron gate valves, NPS OS&Y, Class 125 Class 250	Lubricated plug Valves: Class 125 Class 250, regular gland cylindrical, threaded flanged
Heating-Water Valves	2 and smaller	Bronze angle or globe valves, Class 125 Class 150, bronze PTFE disc, with 250, with flanged ends	Brass or bronze ball valves, one two three piece, with brass bronze stainless steel	-	Bronze valves, NPS RS, Class 125 Class 150, With	-
	2-1/2 and larger	Iron Globe Valves, Class 125 Class 250, with flanged ends	Iron ball valves, Class 125 / Steel ball valves, Class 150	1.) Iron single-flange butterfly valves, NPS 2-1/2 to 12: Aluminum-bronze Ductile-iron Stainless steel disc, 200 CWP, and EPDM NBR seat 2.) Iron single-flange butterfly valves, NPS 14 to 24: Aluminum-bronze Ductile-iron Stainless steel disc, 150 CWP, and EPDM NBR seat 3.) Iron, Grooved-End butterfly valves, NPS 2-1/2 to 12: 175 300 CWP 4.) High performance butterfly valves: Single flange, Class 150 Class 300	Iron gate valves, NPS OS&Y, Class 125 Class 250	1.) Lubricated plug Valves: Class 125 Class 250, regular gland cylindrical, threaded flanged 2.) Eccentric plug valves: 175 CWP, resilient seating
Low-Pressure Steam Valves	2 and smaller	Bronze angle or globe valves, Class 125 Class 150, bronze PTFE disc, with 250, with flanged ends	Brass or bronze ball valves, one two three piece, with brass bronze stainless steel	-	Bronze valves, NPS RS, Class 125 Class 150	-
	2-1/2 and larger	Iron Globe Valves, Class 125 Class 250, with flanged ends	Iron ball valves, Class 125 / Steel ball valves, Class 150	High performance butterfly valves: Single flange, Class 150 Class 300	Iron gate valves, NPS OS&Y, Class 125 Class 250	-
High-Pressure Steam Valves	2 and smaller	Bronze angle or globe valves, Class 125 Class 150, bronze PTFE disc, with 250, with flanged ends	Brass or bronze ball valves, one two three piece, with brass bronze stainless steel	-	Bronze valves, NPS RS, Class 125 Class 150	-
	2-1/2 and larger	Iron Globe Valves, Class 125 Class 250	Iron ball valves, Class 125 / Steel ball valves, Class 300	High performance butterfly valves: Single flange, Class 150 Class 300	Iron gate valves, NPS OS&Y, Class 125 Class 250	-
Steam-Condensate Valves	2 and smaller	Bronze angle or globe valves, Class 125 Class 150, bronze PTFE disc, with 250, with flanged ends	Brass or bronze ball valves, one two three piece, with brass bronze stainless steel	-	Bronze valves, NPS RS, Class 125 Class 150	-
	2-1/2 and larger	Iron Globe Valves, Class 125 Class 250	Iron ball valves, Class 125 / Steel ball valves, Class 300	High performance butterfly valves: Single flange, Class 150 Class 300	Iron gate valves, NPS OS&Y, Class 125 Class 250	Lubricated plug Valves: Class 125 Class 250, regular gland cylindrical, threaded flanged

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all drawings and all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

- B. Related Sections:

Section 05 50 00 – METAL FABRICATIONS

Section 07 72 00 – ROOF ACCESSORIES

Section 23 05 16 – EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

[Section 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC]

[Section 23 05 48.13 – VIBRATION CONTROLS FOR HVAC]

[Section 23 31 13 – METAL DUCTS]

[Section 23 31 16 – NONMETAL DUCTS]

1.3 SUMMARY:

- A. Section Includes:

- 1. Metal pipe hangers and supports.
- 2. Trapeze pipe hangers.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal-hanger shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Equipment supports.

1.4 DEFINITIONS:

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.5 PERFORMANCE REQUIREMENTS:

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to [ASCE/SEI 7] **<Insert requirement>**.
 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 3. Design seismic-restraint hangers and supports for piping and equipment [**and obtain approval from authorities having jurisdiction**].

1.6 ACTION SUBMITTALS:

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: [**Signed and sealed by a qualified professional engineer.**] Show fabrication and installation details and include calculations for the following; include Product Data for components:
 1. Trapeze pipe hangers.
 2. Metal framing systems.
 3. Fiberglass strut systems.
 4. Pipe stands.
 5. Equipment supports.

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- C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

- 1. Detail fabrication and assembly of trapeze hangers.
 - 2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.7 INFORMATIONAL SUBMITTALS:

- A. Welding certificates.

1.8 QUALITY ASSURANCE:

- A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS:

- A. Carbon-Steel Pipe Hangers and Supports:

- 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 - 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**carbon steel**] [**stainless steel**] <Insert material>.

- B. Stainless-Steel Pipe Hangers and Supports:

- 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**stainless steel**] <Insert material>.

- C. Copper Pipe Hangers:

- 1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.

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2. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**copper-coated steel**] [**stainless steel**] <Insert material>.

2.2 TRAPEZE PIPE HANGERS:

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 FIBERGLASS PIPE HANGERS:

- A. Clevis-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
2. Hanger Rods: Continuous-thread rod, washer, and nuts made of [**fiberglass**] [**polyurethane**] [**or**] [**stainless steel**] <Insert material>.

- B. Strap-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
2. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of [**stainless steel**] <Insert material>.

2.4 METAL FRAMING SYSTEMS:

- A. MFMA Manufacturer Metal Framing Systems:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with intumed lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**carbon steel**] [**stainless steel**] <Insert material>.
7. Metallic Coating: [**Electroplated zinc**] [**Hot-dipped galvanized**] [**Mill galvanized**] [**In-line, hot galvanized**] [**Mechanically-deposited zinc**].
8. Paint Coating: [**Vinyl**] [**Vinyl alkyd**] [**Epoxy**] [**Polyester**] [**Acrylic**] [**Amine**] [**Alkyd**] <Insert paint type>.
9. Plastic Coating: [**PVC**] [**Polyurethane**] [**Epoxy**] [**Polyester**] <Insert plastic type>.

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10. Combination Coating: **<Insert coating materials in order of application>.**

B. Non-MFMA Manufacturer Metal Framing Systems:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**carbon steel**] [**stainless steel**] **<Insert material>.**
7. Coating: [**Zinc**] [**Paint**] [**PVC**] **<Insert coating>.**

2.5 FIBERGLASS STRUT SYSTEMS

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.
1. Channels: Continuous slotted fiberglass [**or other plastic**] channel with inturned lips.
 2. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**fiberglass**] [**stainless steel**] **<Insert material>.**

2.6 THERMAL-HANGER SHIELD INSERTS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Insulation-Insert Material for Cold Piping: [**ASTM C 552, Type II cellular glass with 100-psig**] [**or**] [**ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig**] minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: [**Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig**] [**ASTM C 552, Type II cellular glass with 100-psig**] [**or**] [**ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig**] minimum compressive strength.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2-inches beyond sheet metal shield for piping operating below ambient air temperature.

2.7 FASTENER SYSTEMS:

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type, [**zinc-coated**] [**stainless-**] steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.8 PIPE STANDS:

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Low-Type, Single-Pipe Stand: One-piece [**plastic**] [**stainless-steel**] base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand:
 - 1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 2. Base: [**Plastic**] [**Stainless steel**].
 - 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand:
 - 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 2. Bases: One or more; plastic.
 - 3. Vertical Members: Two or more protective-coated-steel channels.
 - 4. Horizontal Member: Protective-coated-steel channel.
 - 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

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- F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.9 EQUIPMENT SUPPORTS:

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.10 MISCELLANEOUS MATERIALS:

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION:

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.
- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.
- F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- G. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4-inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- H. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07 72 00 – ROOF ACCESSORIES for curbs.
- I. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- K. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- L. Install lateral bracing with pipe hangers and supports to prevent swaying.
- M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, [NPS 2-1/2] <Insert size> and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- N. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- P. Insulated Piping:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating Below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12-inches long and 0.048-inch thick.
 - b. NPS 4: 12-inches long and 0.06-inch thick.
 - c. NPS 5 and NPS 6: 18-inches long and 0.06-inch thick.
 - d. NPS 8 to NPS 14: 24-inches long and 0.075-inch thick.
 - e. NPS 16 to NPS 24: 24-inches long and 0.105-inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS:

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS:

- A. Cut, drill, and fit miscellaneous metal fabrications for **[trapeze pipe hangers]** **[and]** **[equipment supports]**.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING:

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to **[1-1/2-inches]** **<Insert dimension>**.

3.5 PAINTING:

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in **[Section 09 91 13 – EXTERIOR PAINTING SCHEDULE]****[Section 09 91 23 – INTERIOR PAINTING SCHEDULE]** **[and]** **[Section 09 96 00 – HIGH PERFORMANCE COATINGS.]**
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE:

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

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- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel [**pipe hangers and supports**] [**metal trapeze pipe hangers**] [**and**] [**metal framing systems**] and attachments for general service applications.
- F. Use [**stainless-steel pipe hangers**] [**and**] [**fiberglass pipe hangers**] [**and**] [**fiberglass strut systems**] and [**stainless-steel**] [**or**] [**corrosion-resistant**] attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and [**copper**] [**or**] [**stainless-steel**] attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg. F, pipes NPS 4 to NPS 24, requiring up to 4-inches of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4-inches of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 - 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 - 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
 - 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
 - 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.

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13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6-inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg. F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg. F piping installations.

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- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

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1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4-inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- R. Use [**powder-actuated fasteners**] [**or**] [**mechanical-expansion anchors**] instead of building attachments where required in concrete construction.

END OF SECTION

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SECTION 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all drawings and all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Related Sections:

[Section 03 30 00 – CAST-IN-PLACE CONCRETE]

[Section 03 30 53 – MISCELLANEOUS CAST-IN-PLACE CONCRETE]

Section 07 72 00 – ROOF ACCESSORIES

Section 23 21 13 – HYDRONIC PIPING

1.3 SUMMARY:

- A. Section Includes:

- 1. Elastomeric isolation pads.
- 2. Elastomeric isolation mounts.
- 3. Restrained elastomeric isolation mounts.
- 4. Open-spring isolators.
- 5. Housed-spring isolators.
- 6. Restrained-spring isolators.
- 7. Housed-restrained-spring isolators.
- 8. Pipe-riser resilient supports.

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9. Resilient pipe guides.
10. Elastomeric hangers.
11. Spring hangers.
12. Snubbers.
13. Restraint channel bracings.
14. Restraint cables.
15. Seismic-restraint accessories.
16. Mechanical anchor bolts.

1.4 ACTION SUBMITTALS:

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.
 1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS:

- A. Welding certificates.
- B. Field quality-control reports.

1.6 QUALITY ASSURANCE:

- A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

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PART 2 - PRODUCTS

EDIT NOTE: PERFORMANCE REQUIREMENTS CAN BE FOUND ON ARCHITECTS CODE SHEET(S). MOST BUILDINGS WILL BE CLASSIFICATION CATEGORY II

2.1 PERFORMANCE REQUIREMENTS:

A. Wind-Restraint Loading:

1. Basic Wind Speed: **<Insert value>**.
2. Building Classification Category: **[I] [II] [III] [IV]**.
3. Minimum 10 lb/sq. ft. multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: **[A] [B] [C] [D] [E] [F]**.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: **[I] [II] [III]**.
 - a. Component Importance Factor: **[1.0] [1.5]**.
 - b. Component Response Modification Factor: **[1.5] [2.5] [3.5] [5.0]**.
 - c. Component Amplification Factor: **[1.0] [2.5]**.
3. Design Spectral Response Acceleration at Short Periods (0.2 Second): **<Insert number>**.
4. Design Spectral Response Acceleration at 1.0-Second Period: **<Insert number>**.

2.2 ELASTOMERIC ISOLATION PADS:

A. Elastomeric Isolation Pads: **<Insert drawing designation>**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mason Industries, Inc.
 - b. Novia; A Division of C&P.
 - c. Vibration Mountings & Controls, Inc.
2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

5. Surface Pattern: [**Smooth**] [**Ribbed**] [**Waffle**] pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.

2.3 ELASTOMERIC ISOLATION MOUNTS:

A. Double-Deflection, Elastomeric Isolation Mounts: **<Insert drawing designation>**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mason Industries, Inc.
 - b. Novia; A Division of C&P.
 - c. Vibration Mountings & Controls, Inc.
2. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded [**with threaded studs or bolts**].
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS:

A. Restrained Elastomeric Isolation Mounts: **<Insert drawing designation>**.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mason Industries, Inc.
 - b. Novia; A Division of C&P.
 - c. Vibration Mountings & Controls, Inc.
2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.5 OPEN-SPRING ISOLATORS:

- A. Freestanding, Laterally Stable, Open-Spring Isolators: **<Insert drawing designation>**.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mason Industries, Inc.
 - b. Novia; A Division of C&P.
 - c. Vibration Mountings & Controls, Inc.
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
 7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 HOUSED-SPRING ISOLATORS:

- A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing: **<Insert drawing designation>**.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Mason Industries, Inc.
 - c. Vibration Mountings & Controls, Inc.
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
- b. Top housing with [attachment and leveling bolt] [threaded mounting holes and internal leveling device] [elastomeric pad].

2.7 RESTRAINED-SPRING ISOLATORS:

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint: <Insert drawing designation>.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mason Industries, Inc.
 - b. Novia; A Division of C&P.
 - c. Vibration Mountings & Controls, Inc.
- 2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
 - b. Top plate with [threaded mounting holes] [elastomeric pad].
 - c. Internal leveling bolt that acts as blocking during installation.
- 3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
- 4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
- 5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
- 6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- 7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS:

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing: <Insert drawing designation>.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mason Industries, Inc.
 - b. Vibration Eliminator Co., Inc.
 - c. Vibration Mountings & Controls, Inc.

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2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with [adjustable] [non-adjustable] snubbers to limit vertical movement.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 PIPE-RISER RESILIENT SUPPORT:

- A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch-thick neoprene <Insert drawing designation>.
 1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 2. Maximum Load Per Support: 500 psigon isolation material providing equal isolation in all directions.

Commented [HE1]: psig of?

2.10 RESILIENT PIPE GUIDES:

- A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene <Insert drawing designation>.
 1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 ELASTOMERIC HANGERS:

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: <Insert drawing designation>.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mason Industries, Inc.
 - b. Novia; A Division of C&P.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

c. [Vibration Mountings & Controls, Inc.](#)

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.12 SPRING HANGERS:

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression: **<Insert drawing designation>**.

1. [Manufacturers](#): Subject to compliance with requirements, provide products by one of the following:
 - a. [Mason Industries, Inc.](#)
 - b. [Novia; A Division of C&P.](#)
 - c. [Vibration Mountings & Controls, Inc.](#)
2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 SNUBBERS:

A. [Manufacturers](#): Subject to compliance with requirements, provide products by one of the following:

1. [Mason Industries, Inc.](#)
2. [Novia; A Division of C&P.](#)

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3. [Vibration Mountings & Controls, Inc.](#)

- B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch-thick resilient cushion.

2.14 RESTRAINT CHANNEL BRACINGS:

- A. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:

1. [Hilti, Inc.](#)
2. [Mason Industries, Inc.](#)
3. [Unistrut; Part of Atkore International.](#)

- B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.15 RESTRAINT CABLES:

- A. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:

1. [Mason Industries, Inc.](#)
2. [Novia; A Division of C&P.](#)
3. [Vibration Mountings & Controls, Inc.](#)

- B. Restraint Cables: [ASTM A 603 galvanized] [ASTM A 492 stainless]-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.16 SEISMIC-RESTRAINT ACCESSORIES:

- A. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:

1. [Mason Industries, Inc.](#)
2. [Novia; A Division of C&P.](#)
3. [Vibration & Seismic Technologies, LLC.](#)

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- B. Hanger-Rod Stiffener: **[Steel tube or steel slotted-support-system sleeve with internally bolted connections]** **[Reinforcing steel angle clamped]** to hanger rod.
- C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.
- D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.
- E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 APPLICATIONS:

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by **[an evaluation service member of ICC-ES]** **[OSHDP]** **[an agency acceptable to authorities having jurisdiction]**.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.2 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION:

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in **[Section 03 30 00 – CAST-IN-PLACE CONCRETE]** **[Section 03 30 53 – MISCELLANEOUS CAST-IN-PLACE CONCRETE]**.
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- C. Comply with requirements in Section 07 72 00 – ROOF ACCESSORIES for installation of roof curbs, equipment supports, and roof penetrations.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

D. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125-inch.
3. Install seismic-restraint devices using methods approved by **[an evaluation service member of ICC-ES] [OSHPD] [an agency acceptable to authorities having jurisdiction]** that provides required submittals for component.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of **[40 feet]** o.c., and longitudinal supports a maximum of **[80 feet]** o.c.
3. Brace a change of direction longer than 12 feet.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install seismic-restraint devices using methods approved by **[an evaluation service member of ICC-ES] [OSHPD] [an agency acceptable to authorities having jurisdiction]** that provides required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

K. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION:

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 23 21 13 – HYDRONIC PIPING for piping flexible connections.

3.4 FIELD QUALITY CONTROL:

- A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least [**four**] <Insert number> of each type and size of installed anchors and fasteners selected by Architect.
 5. Test to 90 percent of rated proof load of device.
 6. Measure isolator restraint clearance.
 7. Measure isolator deflection.
 8. Verify snubber minimum clearances.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.5 ADJUSTING:

- A. Adjust isolators after piping system is at operating weight.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT (FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all drawings and all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections: See Section References for each Division in Section 23 00 50
Division 09 - Finishes

1.3 SUMMARY:

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Duct labels.
 - 5. Valve tags.
 - 6. Miscellaneous Signage
 - 7. Warning tags.

1.4 ACTION SUBMITTALS:

- A. Product Data: For each type of product.

- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS:

A. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Brimar Industries, Inc.
 - c. Seton Identification Products; a Brady Corporation company.
 - d. Or equal
2. Material and Thickness: Multilayer, multicolor, phenolic plastic labels for mechanical engraving, 1/16-inch thick and having predrilled holes for attachment hardware.
3. Letter Color: White.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 200 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2-inch by 3/4-inch.
7. Minimum Letter Size: 1/2-inch for name of units if viewing distance is less than 24-inches, 3/4-inch for viewing distances up to 72-inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Miscellaneous Labels (per drawings):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. [Brady Corporation.](#)
 - b. [Brimar Industries, Inc.](#)
 - c. [Seton Identification Products; a Brady Corporation company.](#)
 - d. Or equal
2. Material and Thickness: Multilayer, multicolor, phenolic plastic labels for mechanical engraving, 1/16-inch thick and having predrilled holes for attachment hardware.
 3. Letter Color: White.
 4. Background Color: Black.
 5. Maximum Temperature: Able to withstand temperatures up to 200 deg F.
 6. Label Size: Length and width vary for required label content, but not less than 2-1/2-inch by 3/4-inch.
 7. Minimum Letter Size: 1/2-inch for name of units if viewing distance is less than 24-inches, 3/4-inch for viewing distances up to 72-inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
 8. Fasteners: Stainless-steel rivets or self-tapping screws.
 9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.2 WARNING SIGNS AND LABELS:

- A. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 1. [Brady Corporation.](#)
 2. [Brimar Industries, Inc.](#)
 3. [Seton Identification Products; a Brady Corporation company.](#)
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch thick and having predrilled holes for attachment hardware.
- C. Letter Color: White.
- D. Background Color: Red.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2-inch by 3/4-inch.
- G. Minimum Letter Size: 1/4-inch for name of units if viewing distance is less than 24-inches, 1/2-inch for viewing distances up to 72-inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

- H. Fasteners: Stainless-steel self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Seton Identification Products; a Brady Corporation company.
 - 4. Or equal
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, pressure sensitive, permanent-adhesive backing.
- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.4 DUCT LABELS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Seton Identification Products; a Brady Corporation company.
 - 4. Or equal
- B. General Requirements for Manufactured Duct Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

- C. Self-Adhesive Duct Labels: Printed plastic with contact-type, pressure sensitive, permanent-adhesive backing.
- D. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; prefix the system with the associated equipment number and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: Size letters according to ASME A13.1 for ductwork.

2.5 VALVE TAGS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Seton Identification Products; a Brady Corporation company.
 - 4. Or equal
- B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.032-inch minimum thickness and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass S-hook.
- C. Valve Schedules: For each piping system, typewritten list with minimum 1/8-inch letters in an anodized aluminum frame and plastic laminated. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.
 - 2. Valve-tag schedule shall be mounted in the mechanical room.

2.6 CEILING TACKS

- A. Provide steel ceiling tacks with a color-coded head 3/4-inch diameter and a 1-1/2-inch serrated shank.
 - 1. Provide ceiling tacks in acoustical tile ceilings to locate equipment, valves or dampers that require regular maintenance or are part of a Life Safety System.
 - 2. Tacks shall be color coded as follows (coordinate with Owner):

- a. Yellow - HVAC equipment
- b. Red - Life Safety (fire dampers, sprinkler valves, etc.)
- c. Green - Plumbing Valves
- d. Blue - Heating/Cooling Valves

2.7 WARNING TAGS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Seton Identification Products; a Brady Corporation company.
- B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
 - 1. Size: Approximately 4-inches by 7-inches.
 - 2. Fasteners: Brass grommet and wire.
 - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Clean piping and equipment surfaces, of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS:

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.
- D. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.
- E. Install tags using corrosion resistant chain. Number tags consecutively by location.
- F. Identify air handling units with plastic nameplates.

- G. Identify control panels and major control components outside panels with plastic nameplates.
- H. Identify valves in main and branch piping with tags.
- I. Identify air terminal units' valves with numbered tags.
- J. Tag automatic controls, instruments, and relays. Key to control schematic.
- K. Provide ceiling tacks to locate valves or dampers above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.3 EQUIPMENT LABEL INSTALLATION:

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Equipment marking shall be prominently located and securely attached with screws or rivets (no adhesives or cements are permitted) on the normally visible side of the equipment.

3.4 PIPE LABEL INSTALLATION:

- A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 20 feet along each run. Increase intervals to 50-feet in areas of long runs or uncongested piping and equipment.
- B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- C. Pipe Label Color Schedule:
 - 1. Chilled-Water Piping: Black letters on a green background.
 - 2. Condenser-Water Piping: Black letters on a green background.
 - 3. Condensate Drain Piping: Black letters on a green background.
 - 4. Make-up Water Piping: Black letters on a green background.

5. Heating Water Piping: Black letters on a yellow background.
6. Refrigerant Piping: Black letters on a yellow background.
7. Steam Piping: Black letters on a yellow background (note: indicate psig of steam system in name).
8. Steam Condensate Piping: Black letters on a yellow background (note: indicate psig of steam system in name).
9. Pumped Steam Condensate Piping: Black letters on a yellow background.
10. Dual Temperature (heating/cooling) Piping: Black letters on a yellow background.

3.5 DUCT LABEL INSTALLATION:

- A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
 1. Blue: For cold-air supply ducts.
 2. Yellow: For hot-air supply ducts.
 3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
- B. Duct Label Locations: Locate duct labels where duct is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 1. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each duct at branch.
 2. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
 3. At access doors, manholes, and similar access points that permit view of concealed piping.
 4. Near major equipment items and other points of origination and termination.
 5. Spaced at maximum intervals of 20 feet along each run. Increase intervals to 50-feet in areas of long runs or uncongested ductwork and equipment.

3.6 VALVE-TAG INSTALLATION:

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

- B. All valves on pipes of every description shall have numbering tags. The valve numbers shall correspond with numbers indicated for valves and controls on two-printed Valve Lists prepared using electronic database by the HVAC Subcontractor. These printed lists shall state the numbers and locations of each valve and control and the section, fixture or equipment which it controls, and other necessary information, such as requiring the opening or closing of another valve when one valve is to be opened or closed.

3.7 WARNING-TAG AND LABEL INSTALLATION:

- A. Write required message on, and attach warning tags and/or labels to, equipment and other items where required.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 – HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contracts, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of the Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

- A. Section Includes:
 - 1. Balancing Air Systems:
 - a. Constant-volume air systems.
 - b. Dual-duct systems.
 - c. Variable-air-volume systems.
 - d. Multizone systems.
 - e. Induction-unit systems.
 - 2. Balancing Hydronic Piping Systems:
 - a. Constant-flow hydronic systems.
 - b. Variable-flow hydronic systems.
 - c. Primary-secondary hydronic systems.
 - 3. Balancing steam systems.
 - 4. Testing, Adjusting, and Balancing Equipment:
 - a. Heat exchangers.
 - b. Motors.
 - c. Chillers.
 - d. Cooling towers.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- e. Condensing units.
 - f. Boilers.
 - g. Heat-transfer coils.
- 5. Testing, adjusting, and balancing existing systems and equipment.
 - 6. Sound tests.
 - 7. Vibration tests.
 - 8. Duct leakage tests.
 - 9. Control system verification.

1.4 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.
- E. TABB: Testing, Adjusting, and Balancing Bureau.
- F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- G. TDH: Total dynamic head.

1.5 PREINSTALLATION MEETINGS

- A. TAB Conference: If requested by the Owner, conduct a TAB conference at [**Project site**] **<Insert location>** after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of [**14**] **<Insert number>** days' advance notice of scheduled meeting time and location.
 - 1. Minimum Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Needs for coordination and cooperation of trades and subcontractors.
 - d. Proposed procedures for documentation and communication flow.

1.6 ACTION SUBMITTALS

- A. Sustainable Design Submittals:
 - 1. <Double click to insert sustainable design text for air balancing or HVAC flushing.>
 - 2. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within [30] [60] [90] <Insert number> days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within [30] [60] [90] <Insert number> days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within [30] [60] [90] <Insert number> days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- D. System Readiness Checklists: Within [30] [60] [90] <Insert number> days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified TAB reports.
- G. Sample report forms.
- H. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.
 - 5. Dates of calibration.

1.8 QUALITY ASSURANCE

- A. TAB Specialists Qualifications: Certified by AABC.
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
 - 2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.
- B. TAB Specialists Qualifications: Certified by [NEBB] [or] [TABB].
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by [NEBB] [or] [TABB].
 - 2. TAB Technician: Employee of the TAB specialist and certified by [NEBB] [or] [TABB] as a TAB technician.
- C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- D. <Double click to insert sustainable design text for air balancing quality assurance requirements.>
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.9 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

- A. Subject to compliance with requirements, **[engage one of the following] [available TAB specialists that may be engaged include, but are not limited to, the following]:**
 - 1. **<Insert TAB specialist's name>.**

3.2 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible, and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 PREPARATION

- A. Prepare a TAB plan that includes the following:
1. Equipment and systems to be tested.
 2. Strategies and step-by-step procedures for balancing the systems.
 3. Instrumentation to be used.
 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
1. Airside:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
- b. Duct systems are complete with terminals installed.
- c. Volume, smoke, and fire dampers are open and functional.
- d. Clean filters are installed.
- e. Fans are operating, free of vibration, and rotating in correct direction.
- f. Variable-frequency controllers' startup is complete, and safeties are verified.
- g. Automatic temperature-control systems are operational.
- h. Ceilings are installed.
- i. Windows and doors are installed.
- j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

- a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
- b. Piping is complete with terminals installed.
- c. Water treatment is complete.
- d. Systems are flushed, filled, and air purged.
- e. Strainers are pulled and cleaned.
- f. Control valves are functioning per the sequence of operation.
- g. Shutoff and balance valves have been verified to be 100 percent open.
- h. Pumps are started and proper rotation is verified.
- i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
- j. Variable-frequency controllers' startup is complete, and safeties are verified.
- k. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in [AABC's "**National Standards for Total System Balance**"] [ASHRAE 111] [NEBB's "**Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems**"] [SMACNA's "**HVAC Systems - Testing, Adjusting, and Balancing**"] and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00 "Air Duct Accessories."
 3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 13 "Duct Insulation," Section 23 07 16 "HVAC Equipment Insulation," and Section 23 07 19 "HVAC Piping Insulation."

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 23 31 13 "Metal Ducts."

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses, close to the fan and prior to any outlets, to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

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2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 4. Obtain approval from [Architect] [Owner] [Construction Manager] [commissioning authority] for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
 2. Adjust submain and branch duct volume dampers for specified airflow.
 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 2. Measure inlets and outlets airflow.
 3. Adjust each inlet and outlet for specified airflow.
 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
 2. Re-measure and confirm that total airflow is within design.
 3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
 4. Mark all final settings.
 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
 6. Measure and record all operating data.
 7. Record final fan-performance data.

3.7 PROCEDURES FOR DUAL-DUCT SYSTEMS

- A. Adjust the dual-duct systems as follows:

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1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge. On systems with separate hot-deck and cold-deck fans, verify the location of the sensor on each deck.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit's hot deck and cold deck for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for full cooling. Some controllers require starting with minimum set point. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factors as required for design cold-deck maximum airflow and hot-deck minimum airflow. Record calibration factors.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for full heating.
 - e. Measure airflow and adjust calibration factors as required for design cold-deck minimum airflow and hot-deck maximum airflow. Record calibration factors. If no minimum calibration is available, note any deviation from design airflow.
5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Set terminals for maximum airflow. If system design includes diversity (cooling coil or fan), adjust terminals for maximum and minimum airflow so that connected total matches cooling coil or fan selection and simulates actual load in the building. In systems with separate hot-deck and cold-deck fans, diversity consideration applies to each individual fan.
 - c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
6. Measure the fan(s) static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan(s) while operating at maximum return airflow and minimum outdoor airflow.

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- a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - b. Verify that all terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.
 - c. Re-measure final fan operating data, rpms, volts, amps and static profile.
 - d. Mark final settings.
 - e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
 - f. Verify tracking between supply and return fans.
10. Record final fan-performance data.

3.8 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.
 - e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.

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- g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
- 5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
 - c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
- 6. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
- 7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
- 8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
- 9. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.
 - c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
 - d. Mark final settings.
 - e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
 - f. Verify tracking between supply and return fans.

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3.9 PROCEDURES FOR MULTIZONE SYSTEMS

- A. Position the unit's automatic zone dampers for maximum flow through the cooling coil.
- B. The procedures for multizone systems will utilize the zone balancing dampers to achieve the indicated airflow within the zone.
- C. After balancing, place the unit's automatic zone dampers for maximum heating flow. Retest zone airflows and record any variances.
- D. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air and relief-air dampers for proper position that simulates minimum outdoor air conditions.
 - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 - 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 4. Obtain approval from [Architect] [Owner] [Construction Manager] [commissioning authority] for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 - 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- E. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts.
 - 2. Adjust submain and branch duct volume dampers for specified airflow.
 - 3. Re-measure each submain and branch duct after all have been adjusted.

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- F. Adjust air inlets and outlets for each space to indicated airflows.
 - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 - 2. Measure inlets and outlets airflow.
 - 3. Adjust each inlet and outlet for specified airflow.
 - 4. Re-measure each inlet and outlet after they have been adjusted.
- G. Verify final system conditions.
 - 1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - 2. Re-measure and confirm that total airflow is within design.
 - 3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
 - 4. Mark all final settings.
 - 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
 - 6. Measure and record all operating data.
 - 7. Record final fan-performance data.

3.10 PROCEDURES FOR INDUCTION-UNIT SYSTEMS

- A. Balance primary-air risers by measuring static pressure at the nozzles of the top and bottom units of each riser to determine which risers must be throttled. Adjust risers to indicated airflow within specified tolerances.
- B. Adjust each induction unit.
- C. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.

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3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 4. Obtain approval from [Architect] [Owner] [Construction Manager] [commissioning authority] for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- D. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
 2. Adjust submain and branch duct volume dampers for specified airflow.
 3. Re-measure each submain and branch duct after all have been adjusted.
- E. Balance airflow to each induction unit by measuring the nozzle pressure and comparing it to the manufacturer's published data for nozzle pressure versus cfm. Adjust the unit's inlet damper to achieve the required nozzle pressure for design cfm.
- F. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 2. Re-measure and confirm that total airflow is within design.
 3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
 4. Mark all final settings.
 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
 6. Measure and record all operating data.
 7. Record final fan-performance data.

3.11 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
1. Check liquid level in expansion tank.
 2. Check highest vent for adequate pressure.
 3. Check flow-control valves for proper position.
 4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

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5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

3.12 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gage heights.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

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- E. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - 1. Measure and balance coils by either coil pressure drop or temperature method.
 - 2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- F. Verify final system conditions as follows:
 - 1. Re-measure and confirm that total water flow is within design.
 - 2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 - 3. Mark final settings.
- G. Verify that memory stops have been set.

3.13 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.
- B. Adjust the variable-flow hydronic system as follows:
 - 1. Verify that the differential-pressure sensor is located as indicated.
 - 2. Determine whether there is diversity in the system.
- C. For systems with no diversity:
 - 1. Adjust pumps to deliver total design gpm.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gage heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

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2. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
 3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
 4. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
 5. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
 6. Prior to verifying final system conditions, determine the system differential-pressure set point.
 7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
 8. Mark final settings and verify that all memory stops have been set.
 9. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 - c. Mark final settings.
 10. Verify that memory stops have been set.
- D. For systems with diversity:
1. Determine diversity factor.
 2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
 3. Adjust pumps to deliver total design gpm.
 - a. Measure total water flow.

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- 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gage heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
4. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
 5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
 6. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
 7. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
 8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.

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9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 - c. Mark final settings.
13. Verify that memory stops have been set.

3.14 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

- A. Balance the primary circuit flow first.
- B. Balance the secondary circuits after the primary circuits are complete.
- C. Adjust pumps to deliver total design gpm.
 1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gage heights.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- D. Adjust flow-measuring devices installed in mains and branches to design water flows.
 1. Measure flow in main and branch pipes.
 2. Adjust main and branch balance valves for design flow.

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3. Re-measure each main and branch after all have been adjusted.
- E. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 1. Measure flow at terminals.
 2. Adjust each terminal to design flow.
 3. Re-measure each terminal after it is adjusted.
 4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
 5. Perform temperature tests after flows have been balanced.
- F. For systems with pressure-independent valves at terminals:
 1. Measure differential pressure and verify that it is within manufacturer's specified range.
 2. Perform temperature tests after flows have been verified.
- G. For systems without pressure-independent valves or flow-measuring devices at terminals:
 1. Measure and balance coils by either coil pressure drop or temperature method.
 2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- H. Verify final system conditions as follows:
 1. Re-measure and confirm that total water flow is within design.
 2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 3. Mark final settings.
- I. Verify that memory stops have been set.

3.15 PROCEDURES FOR STEAM SYSTEMS

- A. Measure and record upstream and downstream pressure of each piece of equipment.
- B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.
- C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
- D. Check settings and operation of each safety valve. Record settings.
- E. Verify the operation of each steam trap.

3.16 PROCEDURES FOR HEAT EXCHANGERS

- A. Adjust water flow to within specified tolerances.
- B. Measure inlet and outlet water temperatures.
- C. Measure inlet steam pressure.

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- D. Check settings and operation of safety and relief valves. Record settings.

3.17 PROCEDURES FOR MOTORS

- A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 - 1. Manufacturer's name, model number, and serial number.
 - 2. Motor horsepower rating.
 - 3. Motor rpm.
 - 4. Phase and hertz.
 - 5. Nameplate and measured voltage, each phase.
 - 6. Nameplate and measured amperage, each phase.
 - 7. Starter size and thermal-protection-element rating.
 - 8. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.18 PROCEDURES FOR CHILLERS

- A. Balance water flow through each evaporator[**and condenser**] to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 - 1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
 - 2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
 - 3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
 - 4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
 - 5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
 - 6. Capacity: Calculate in tons of cooling.
 - 7. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.19 PROCEDURES FOR COOLING TOWERS

- A. Balance total condenser-water flows to towers. Measure and record the following data:
 - 1. Condenser-water flow to each cell of the cooling tower.
 - 2. Entering- and leaving-water temperatures.
 - 3. Wet- and dry-bulb temperatures of entering air.
 - 4. Wet- and dry-bulb temperatures of leaving air.
 - 5. Condenser-water flow rate recirculating through the cooling tower.
 - 6. Cooling-tower spray pump discharge pressure.
 - 7. Condenser-water flow through bypass.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

8. Fan and motor operating data.

3.20 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record fan and motor operating data.

3.21 PROCEDURES FOR BOILERS

- A. Hydronic Boilers:
 1. Measure and record entering- and leaving-water temperatures.
 2. Measure and record water flow.
 3. Record relief valve pressure setting.
- B. Steam Boilers:
 1. Measure and record entering-water temperature.
 2. Measure and record feed water flow.
 3. Measure and record leaving-steam pressure and temperature.
 4. Record relief valve pressure setting.

3.22 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each water coil:
 1. Entering- and leaving-water temperature.
 2. Water flow rate.
 3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
 4. Dry-bulb temperature of entering and leaving air.
 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 6. Airflow.
- B. Measure, adjust, and record the following data for each electric heating coil:
 1. Nameplate data.
 2. Airflow.
 3. Entering- and leaving-air temperature at full load.
 4. Voltage and amperage input of each phase at full load.
 5. Calculated kilowatt at full load.
 6. Fuse or circuit-breaker rating for overload protection.
- C. Measure, adjust, and record the following data for each steam coil:
 1. Dry-bulb temperature of entering and leaving air.

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2. Airflow.
3. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.23 SOUND TESTS

A. After the systems are balanced and construction is Substantially Complete, measure and record sound levels at [5] [10] [15] <Insert number> locations as designated by the Architect.

B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels and measuring the equivalent continuous sound pressure level (LEQ).
3. The sound-testing meter must be capable of using 1/3 octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight un-weighted octave bands [63 Hz to 8000 Hz (NC)] [31.5 Hz to 4000 Hz (RC)] with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight un-weighted octave bands [63 Hz to 8000 Hz (NC)] [31.5 Hz to 4000 Hz (RC)] with the equipment operating.
7. Take readings no closer than 36- inches from a wall or from the operating equipment and approximately 60-inches from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:
 - a. Location.
 - b. System tested.

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- c. dBA reading.
 - d. Sound pressure level in each octave band with equipment on and off.
2. Plot sound pressure levels on [NC] [RC] worksheet with equipment on and off.

3.24 VIBRATION TESTS

- A. After systems are balanced and construction is Substantially Complete, measure and record vibration levels on equipment having motor horsepower equal to or greater than [10] [15] [25]<Insert number>.
- B. Instrumentation:
- 1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
 - 2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
 - 3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
 - 4. Verify calibration date is current for vibration meter before taking readings.
- C. Test Procedures:
- 1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
 - 2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.
 - 3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
 - 4. Record CPM or rpm.
 - 5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.
- D. Reporting:
- 1. Report shall record location and the system tested.
 - 2. Include horizontal-vertical-axial measurements for tests.
 - 3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from the AABC National Standards. Acceptable levels of vibration are normally "smooth" to "good."
 - 4. Include in report General Machinery Vibration Severity Chart, with conditions plotted.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3.25 DUCT LEAKAGE TESTS

- A. Witness the duct pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- C. Report deficiencies observed.

3.26 CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 - 1. Verify temperature control system is operating within the design limitations.
 - 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 - 3. Verify that controllers are calibrated and function as intended.
 - 4. Verify that controller set points are as indicated.
 - 5. Verify the operation of lockout or interlock systems.
 - 6. Verify the operation of valve and damper actuators.
 - 7. Verify that controlled devices are properly installed and connected to correct controller.
 - 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
 - 9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.
- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.27 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

- A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
 - 1. Measure and record the operating speed, airflow, and static pressure of each fan.
 - 2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
 - 3. Check the refrigerant charge.
 - 4. Check the condition of filters.
 - 5. Check the condition of coils.
 - 6. Check the operation of the drain pan and condensate-drain trap.
 - 7. Check bearings and other lubricated parts for proper lubrication.
 - 8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
- B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
 - 1. New filters are installed.
 - 2. Coils are clean and fins combed.
 - 3. Drain pans are clean.

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4. Fans are clean.
 5. Bearings and other parts are properly lubricated.
 6. Deficiencies noted in the preconstruction report are corrected.
- C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
1. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan speed and the face velocity of filters and coils.
 2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
 3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
 4. Balance each air outlet.

3.28 TOLERANCES

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans and Equipment with Fans: [**Plus or minus 10 percent**] **<Insert value>**.
 2. Air Outlets and Inlets: [**Plus or minus 10 percent**] **<Insert value>**.
 3. Heating-Water Flow Rate: [**Plus or minus 10 percent**] **<Insert value>**.
 4. Cooling-Water Flow Rate: [**Plus or minus 10 percent**] **<Insert value>**.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.29 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare [**weekly**] [**biweekly**] [**monthly**] **<Insert time interval>** progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.30 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 2. Include a list of instruments used for procedures, along with proof of calibration.
 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
1. Pump curves.
 2. Fan curves.
 3. Manufacturers' test data.
 4. Field test reports prepared by system and equipment installers.
 5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
 2. Name and address of the TAB specialist.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Filter static-pressure differential in inches wg.
 - f. Preheat-coil static-pressure differential in inches wg.
 - g. Cooling-coil static-pressure differential in inches wg.
 - h. Heating-coil static-pressure differential in inches wg.
 - i. Outdoor airflow in cfm.
 - j. Return airflow in cfm.
 - k. Outdoor-air damper position.
 - l. Return-air damper position.
 - m. Vortex damper position.

F. Apparatus-Coil Test Reports:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Coil Data:

- a. System identification.
- b. Location.
- c. Coil type.
- d. Number of rows.
- e. Fin spacing in fins per inch o.c.
- f. Make and model number.
- g. Face area in sq. ft..
- h. Tube size in NPS.
- i. Tube and fin materials.
- j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

- a. Airflow rate in cfm.
- b. Average face velocity in fpm.
- c. Air pressure drop in inches wg.
- d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
- e. Return-air, wet- and dry-bulb temperatures in deg F.
- f. Entering-air, wet- and dry-bulb temperatures in deg F.
- g. Leaving-air, wet- and dry-bulb temperatures in deg F.
- h. Water flow rate in gpm.
- i. Water pressure differential in feet of head or psig.
- j. Entering-water temperature in deg F.
- k. Leaving-water temperature in deg F.
- l. Refrigerant expansion valve and refrigerant types.
- m. Refrigerant suction pressure in psig.
- n. Refrigerant suction temperature in deg F.
- o. Inlet steam pressure in psig.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

- a. System identification.
- b. Location.
- c. Make and type.
- d. Model number and unit size.
- e. Manufacturer's serial number.
- f. Fuel type in input data.
- g. Output capacity in Btu/h.
- h. Ignition type.
- i. Burner-control types.
- j. Motor horsepower and rpm.
- k. Motor volts, phase, and hertz.
- l. Motor full-load amperage and service factor.
- m. Sheave make, size in inches, and bore.
- n. Center-to-center dimensions of sheave and amount of adjustments in inches.

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2. Test Data (Indicated and Actual Values):

- a. Total airflow rate in cfm.
- b. Entering-air temperature in deg F.
- c. Leaving-air temperature in deg F.
- d. Air temperature differential in deg F.
- e. Entering-air static pressure in inches wg.
- f. Leaving-air static pressure in inches wg.
- g. Air static-pressure differential in inches wg.
- h. Low-fire fuel input in Btu/h.
- i. High-fire fuel input in Btu/h.
- j. Manifold pressure in psig.
- k. High-temperature-limit setting in deg F.
- l. Operating set point in Btu/h.
- m. Motor voltage at each connection.
- n. Motor amperage for each phase.
- o. Heating value of fuel in Btu/h.

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

- a. System identification.
- b. Location.
- c. Coil identification.
- d. Capacity in Btu/h.
- e. Number of stages.
- f. Connected volts, phase, and hertz.
- g. Rated amperage.
- h. Airflow rate in cfm.
- i. Face area in sq. ft..
- j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

- a. Heat output in Btu/h.
- b. Airflow rate in cfm.
- c. Air velocity in fpm.
- d. Entering-air temperature in deg F.
- e. Leaving-air temperature in deg F.
- f. Voltage at each connection.
- g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

- a. System identification.
- b. Location.
- c. Make and type.

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- d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave and amount of adjustments in inches.
- 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - g. Number, make, and size of belts.
- 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft..
 - g. Indicated airflow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual airflow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- K. Air-Terminal-Device Reports:
 - 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.

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- g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft..
- 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.
- L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 - 1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Entering-water temperature in deg F.
 - c. Leaving-water temperature in deg F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.
- M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model number and serial number.
 - f. Water flow rate in gpm.
 - g. Water pressure differential in feet of head or psig.
 - h. Required net positive suction head in feet of head or psig.
 - i. Pump rpm.
 - j. Impeller diameter in inches.
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.

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- n. Amperage for each phase.
 - o. Full-load amperage and service factor.
 - p. Seal type.
2. Test Data (Indicated and Actual Values):
- a. Static head in feet of head or psig.
 - b. Pump shutoff pressure in feet of head or psig.
 - c. Actual impeller size in inches.
 - d. Full-open flow rate in gpm.
 - e. Full-open pressure in feet of head or psig.
 - f. Final discharge pressure in feet of head or psig.
 - g. Final suction pressure in feet of head or psig.
 - h. Final total pressure in feet of head or psig.
 - i. Final water flow rate in gpm.
 - j. Voltage at each connection.
 - k. Amperage for each phase.

N. Instrument Calibration Reports:

1. Report Data:
- a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.31 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of [Architect] [Owner] [Construction Manager] [commissioning authority].
- B. [Architect] [Owner] [Construction Manager] [Commissioning authority] shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- E. If TAB work fails, proceed as follows:
 - 1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, **[Owner]** **[design professional]** **[Architect]** may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.32 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

SECTION 23 07 13

DUCT INSULATION
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY:

- A. Section includes insulating the following duct services:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
 - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 - 7. Outdoor
- B. Related Sections:
 - 1. Section 23 07 16 "HVAC Equipment Insulation."
 - 2. Section 23 07 19 "HVAC Piping Insulation."
 - 3. Section 23 31 13 "Metal Ducts" for duct liners.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1.4 ACTION SUBMITTALS:

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
 - 3. Detail application of field-applied jackets.
 - 4. Detail application at linkages of control devices.

1.5 INFORMATIONAL SUBMITTALS:

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency, acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

1.6 QUALITY ASSURANCE:

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.7 DELIVERY, STORAGE, AND HANDLING:

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1.8 COORDINATION:

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.9 SCHEDULING:

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS:

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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- a. Or Equal.
 - b. [Aeroflex USA.](#)
 - c. [Armacell LLC.](#)
- G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- 1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. [CertainTeed Corporation; Saint-Gobain North America.](#)
 - c. [Johns Manville; a Berkshire Hathaway company.](#)
 - d. [Knauf Insulation.](#)
 - e. [Manson Insulation Inc.](#)
 - f. [Owens Corning.](#)
- H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- 1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. [CertainTeed Corporation; Saint-Gobain North America.](#)
 - c. [Johns Manville; a Berkshire Hathaway company.](#)
 - d. [Knauf Insulation.](#)
 - e. [Manson Insulation Inc.](#)
 - f. [Owens Corning.](#)
- I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb./cu. ft. or more. Thermal conductivity (k-value) at 100 deg. F is 0.29 Btu x in./h x sq. ft. x deg. F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- 1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. [CertainTeed Corporation; Saint-Gobain North America.](#)
 - c. [Johns Manville; a Berkshire Hathaway company.](#)
 - d. [Knauf Insulation.](#)
 - e. [Manson Insulation Inc.](#)
 - f. [Owens Corning.](#)

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2.2 ADHESIVES:

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. **Manufacturers:** Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Or Equal.
 - b. [Childers Brand; H. B. Fuller Construction Products.](#)
 - c. [Eagle Bridges - Marathon Industries.](#)
 - d. [Foster Brand; H. B. Fuller Construction Products.](#)
 - e. [Mon-Eco Industries, Inc.](#)
- C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 - a. [Childers Brand; H. B. Fuller Construction Products.](#)
 - b. [Eagle Bridges - Marathon Industries.](#)
 - c. [Foster Brand; H. B. Fuller Construction Products.](#)
 - d. [Mon-Eco Industries, Inc.](#)
- D. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. [Johns Manville; a Berkshire Hathaway company.](#)

2.3 MASTICS:

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
 - 1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. [Childers Brand; H. B. Fuller Construction Products.](#)
 - c. [Foster Brand; H. B. Fuller Construction Products.](#)

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- d. [Knauf Insulation.](#)
 - 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg. F.
 - 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 5. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
- 1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. [Childers Brand; H. B. Fuller Construction Products.](#)
 - c. [Eagle Bridges - Marathon Industries.](#)
 - d. [Foster Brand; H. B. Fuller Construction Products.](#)
 - 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
 - 3. Service Temperature Range: Minus 50 to plus 220 deg. F.
 - 4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - 5. Color: White.
- D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
- 1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. [Childers Brand; H. B. Fuller Construction Products.](#)
 - c. [Eagle Bridges - Marathon Industries.](#)
 - d. [Foster Brand; H. B. Fuller Construction Products.](#)
 - e. [Knauf Insulation.](#)
 - 2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg. F.
 - 4. Solids Content: 60 percent by volume and 66 percent by weight.
 - 5. Color: White.

2.4 LAGGING ADHESIVES:

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. Childers Brand; H. B. Fuller Construction Products.
 - c. Foster Brand; H. B. Fuller Construction Products.
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
3. Service Temperature Range: 0 to plus 180 deg. F.
4. Color: White.

2.5 SEALANTS:

A. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. Childers Brand; H. B. Fuller Construction Products.
 - c. Eagle Bridges - Marathon Industries.
 - d. Foster Brand; H. B. Fuller Construction Products.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg. F.
5. Color: Aluminum.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Or Equal.
 - b. Childers Brand; H. B. Fuller Construction Products.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg. F.
5. Color: White.

2.6 FACTORY-APPLIED JACKETS:

- ### A.
- Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

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1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED JACKETS:

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Or Equal.
 - b. Johns Manville; a Berkshire Hathaway company.
 2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: White.
- D. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with stucco-embossed aluminum-foil facing.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. Polyguard Products, Inc.

2.8 TAPES:

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 2. Width: 3-inches.
 3. Thickness: 11.5 mils.
 4. Adhesion: 90 ounces' force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 2. Width: 3-inches.
 3. Thickness: 6.5 mils.
 4. Adhesion: 90 ounces' force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Or Equal.
 - b. Ideal Tape Co., Inc., an American Biltrite Company.
 2. Width: 2-inches.
 3. Thickness: 6 mils.
 4. Adhesion: 64 ounces' force/inch in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
2. Width: 2-inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces' force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS:

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. RPR Products, Inc.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch-thick, ¾-inch wide with wing seal or closed seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Or Equal.
 - 2) Midwest Fasteners, Inc.
 - 3) Nelson Stud Welding.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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- 1) Or Equal.
 - 2) [Gemco.](#)
 - 3) [Midwest Fasteners, Inc.](#)
 - 4) [Nelson Stud Welding.](#)
 3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2-inches in diameter.
 - a. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - 1) Or Equal.
 - 2) [Gemco.](#)
 - 3) [Midwest Fasteners, Inc.](#)
 - 4) [Nelson Stud Welding.](#)
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 - C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.
 - D. Wire: 0.080-inch nickel-copper alloy.
 1. [Manufacturers:](#) Subject to compliance with requirements, provide products by one of the following:
 - a. Or Equal.
 - b. [C & F Wire.](#)
- 2.10 CORNER ANGLES:
- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1-inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
 - B. Aluminum Corner Angles: 0.040-inch thick, minimum 1 by 1-inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.
 - C. Stainless-Steel Corner Angles: 0.024-inch thick, minimum 1 by 1-inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

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1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION:

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS:

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

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- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4-inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2-inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4-inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS:

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2-inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor

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- insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2-inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
 - C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
 - D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2-inches.
 - 1. Comply with requirements in Section 07 84 13 "Penetration Firestopping."
 - E. Insulation Installation at Floor Penetrations:
 - 1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."
- 3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION:
- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- 3.6 INSTALLATION OF MINERAL-FIBER INSULATION:
- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18-inches and smaller, place pins along longitudinal centerline of duct. Space 3-inches maximum from insulation end joints, and 16-inches o.c.

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- b. On duct sides with dimensions larger than 18-inches, place pins 16-inches o.c. each way, and 3-inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2-inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg. F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3-inches.
 - 5. Overlap unfaced blankets a minimum of 2-inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18-inches o.c.
 - 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 - 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6-inches o.c.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
- 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. On duct sides with dimensions 18-inches and smaller, place pins along longitudinal centerline of duct. Space 3-inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18-inches, space pins 16-inches o.c. each way, and 3-inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2-inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg. F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3-inches.
 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6-inches o.c.

3.7 FIELD-APPLIED JACKET INSTALLATION:

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:

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1. Draw jacket material smooth and tight.
 2. Install lap or joint strips with same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12-inches o.c. and at end joints.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION:

- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- B. Insulate duct access panels and doors to achieve same fire rating as duct.
- C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.9 FINISHES:

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 91 13 "Exterior Painting" and Section 09 91 23 "Interior Painting."
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- D. Do not field paint aluminum or stainless-steel jackets.

3.10 FIELD QUALITY CONTROL:

- A. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 DUCT INSULATION SCHEDULE, GENERAL:

- A. See Drawing Schedule Sheet(s)
- B. Items Not Insulated:
 - 1. Fibrous-glass ducts.
 - 2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 - 3. Factory-insulated flexible ducts.
 - 4. Factory-insulated plenums and casings.
 - 5. Flexible connectors.
 - 6. Vibration-control devices.
 - 7. Factory-insulated access panels and doors.

3.12 INDOOR DUCT AND PLENUM INSULATION SCHEDULE:

- A. Round and flat-oval duct insulation shall be Mineral-Fiber Blanket:
- B. Rectangular duct insulation shall be Mineral-Fiber Board.
- C. Outdoor-air plenum insulation shall be Mineral-Fiber Board

3.13 OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE:

- A. Round outdoor duct insulation shall be Mineral-Fiber Board with stick on aluminum stucco facing rated for outdoor use.

END OF SECTION

SECTION 23 07 19

HVAC PIPING INSULATION (FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

- A. Section includes insulation for HVAC piping systems.
- B. Related Sections:
 - 1. Section 23 07 13 "Duct Insulation" for duct insulation.
 - 2. Section 23 07 16 "HVAC Equipment Insulation" for equipment insulation.
 - 3. Section 23 21 13.13 "Underground Hydronic Piping" loose-fill pipe insulation in underground piping outside the building.
 - 4. Section 33 63 13 "Underground Steam and Condensate Distribution Piping" for loose-fill pipe insulation in underground piping outside the building.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. Sustainable Design Submittals:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. [<Double click to insert sustainable design text for adhesives, mastics, and sealants submittals.>](#)
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 2. Detail attachment and covering of heat tracing inside insulation.
 3. Detail insulation application at pipe expansion joints for each type of insulation.
 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 5. Detail removable insulation at piping specialties.
 6. Detail application of field-applied jackets.
 7. Detail application at linkages of control devices.
- D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.
1. Preformed Pipe Insulation Materials: 12-inches long by NPS 2.
 2. Sheet Form Insulation Materials: 12-inches square.
 3. Jacket Materials for Pipe: 12-inches long by NPS 2.
 4. Sheet Jacket Materials: 12-inches square.
 5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
- B. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
1. Piping Mockups:
 - a. One 10-foot section of NPS 2 straight pipe.
 - b. One each of a 90-degree threaded, welded, and flanged elbow.
 - c. One each of a threaded, welded, and flanged tee fitting.
 - d. One NPS 2 or smaller valve and one NPS 2-1/2 or larger valve.
 - e. Four support hangers, including hanger shield and insert.
 - f. One threaded strainer and one flanged strainer with removable portion of insulation.
 - g. One threaded reducer and one welded reducer.
 - h. One pressure temperature tap.
 - i. One mechanical coupling.
 - j. One union.
 - k. **<Insert mockup>**
 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
 3. Notify Architect **[seven]** **<Insert number>** days in advance of dates and times when mockups will be constructed.
 4. Obtain Architect's approval of mockups before starting insulation application.
 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 7. Demolish and remove mockups when directed.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1.8 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.9 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Calcium Silicate: Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
 2. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Preformed Pipe Insulation: Type II, Class 1, without jacket.
 3. Preformed Pipe Insulation: Type II, Class 2, with factory-applied [ASJ] [ASJ-SSL] jacket.
 4. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
 5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- H. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type I for tubular materials, Type II for sheet materials.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- I. Mineral-Fiber, Preformed Pipe: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Preformed Pipe Insulation: Type I, Grade A[, **without factory-applied jacket**][**with factory-applied ASJ**][**with factory-applied ASJ-SSL**].
 3. 850 deg F.
 4. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
 5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- J. Mineral-Fiber, Pipe and Tank: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C1393.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Semirigid board material with factory-applied [ASJ] [FSK] jacket.
 3. Nominal density is 2.5 lb/cu. ft. or more.
 4. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- K. Phenolic: Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C1126.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Preformed Pipe Insulation: Type III[, **without factory-applied jacket**] [, **with factory-applied ASJ**].
 3. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
 4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- L. Polyisocyanurate: Preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation. Comply with ASTM C591.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Preformed insulation[, **without factory-applied jacket**] [, **with factory-applied ASJ**] [, **with factory-applied ASJ-SSL**] [, **with field-applied PVDC jacket**] [, **with field-applied PVDC-SSL**].
 3. Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
 4. Flame-spread index shall be 25 or less, and smoke-developed index shall be 50 or less for thicknesses of up to 1-inch as tested in accordance with ASTM E84.
 5. Fabricate shapes in accordance with ASTM C450 and ASTM C585.
 6. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- M. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534/C534M or ASTM C1427, Type I, Grade 1, for tubular materials and with Type II, Grade 1, for sheet materials.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- N. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging. Fabricate shapes in accordance with ASTM C450 and ASTM C585.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C195.
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. [<Double click to insert sustainable design text for calcium silicate adhesive VOC content.>](#)
 - 3. [<Double click to insert sustainable design text for low emitting adhesives.>](#)
- C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. [<Double click to insert sustainable design text for cellular glass adhesive VOC Content.>](#)
 - 3. [<Double click to insert sustainable design text for low emitting adhesives.>](#)
- D. Phenolic and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. [<Double click to insert sustainable design text for phenolic and polyisocyanurate adhesive VOC content.>](#)
 3. [<Double click to insert sustainable design text for low emitting adhesives.>](#)
- E. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. [<Double click to insert sustainable design text for adhesive for flexible elastomeric and polyolefin VOC content.>](#)
 3. [<Double click to insert sustainable design text for low emitting adhesives.>](#)
 4. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
 5. Wet Flash Point: Below 0 deg F.
 6. Service Temperature Range: 40 to 200 deg F.
 7. Color: [Black] **<Insert color>**.
- F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. [<Double click to insert sustainable design text for mineral fiber adhesive VOC content>](#)
 3. [<Double click to insert sustainable design text for low emitting adhesives.>](#)
- G. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. [<Double click to insert sustainable design text for polystyrene adhesive VOC content.>](#)
 3. [<Double click to insert sustainable design text for low emitting adhesives.>](#)
- H. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. [<Double click to insert sustainable design text for adhesive for ASJ, FSK, and PVDC jackets VOC content.>](#)
 3. [<Double click to insert sustainable design text for low emitting adhesives.>](#)
- I. PVC Jacket Adhesive: Compatible with PVC jacket.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. [<Double click to insert sustainable design text for adhesive for PVC jacket>](#)
3. [<Double click to insert sustainable design text for low emitting adhesives.>](#)

2.4 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
1. [<Double click to insert sustainable design text for insulation mastics VOC content.>](#)
 2. [<Double click to insert sustainable design text for low-emitting mastics VOC content.>](#)
- B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: **[0 to plus 180 deg F] [Minus 20 to plus 180 deg F]**.
 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements[, **with supplier listing on DOD QPD - Qualified Products Database**].
 5. Color: **[White]** **<Insert color>**.
- C. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: 0 to 180 deg F.
 4. Color: **[White]** **<Insert color>**.
- D. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: Minus 50 to plus 220 deg F.
 4. Color: **[White]** **<Insert color>**.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range: [0 to plus 180 deg F] [Minus 20 to plus 180 deg F].
4. Color: [White] <Insert color>.

2.5 LAGGING ADHESIVES

- A. Adhesives shall comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. [<Double click to insert sustainable design text for lagging adhesives.>](#)
 3. [<Double click to insert sustainable design text for low emitting adhesives.>](#)
 4. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
 5. Service Temperature Range: [20 to plus 180 deg F] [0 to plus 180 deg F].
 6. Color: White.

2.6 SEALANTS

- A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Permanently flexible, elastomeric sealant.
 - a. Service Temperature Range: [Minus 150 to plus 250 deg F] [Minus 100 to plus 300 deg F].
 - b. Color: White or gray.
 3. [<Double click to insert sustainable design text for sealant.>](#)
 4. [<Double click to insert sustainable design text for sealants.>](#)
- C. FSK and Metal Jacket Flashing Sealants:
 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F.
 4. Color: Aluminum.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

5. [<Double click to insert sustainable design text for sealant.>](#)
6. [<Double click to insert sustainable design text for sealants.>](#)

D. ASJ Flashing Sealants and PVDC and PVC Jacket Flashing Sealants:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.
5. [<Double click to insert sustainable design text for sealant.>](#)
6. [<Double click to insert sustainable design text for sealants.>](#)

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2.9 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2.10 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C1136, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: [White] **[Color-code jackets based on system. Color as selected by Architect].**
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

D. Metal Jacket:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. **[Sheet and roll stock ready for shop or field sizing] [Factory cut and rolled to size].**
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: **[1-mil-thick, heat-bonded polyethylene and kraft paper] [3-mil-thick, heat-bonded polyethylene and kraft paper] [2.5-mil-thick polysurlyn].**
 - d. Moisture Barrier for Outdoor Applications: **[3-mil-thick, heat-bonded polyethylene and kraft paper] [2.5-mil-thick polysurlyn].**
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
3. Stainless-Steel Jacket: ASTM A240/A240M.
 - a. **[Sheet and roll stock ready for shop or field sizing] [Factory cut and rolled to size].**
 - b. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: **[1-mil-thick, heat-bonded polyethylene and kraft paper] [3-mil-thick, heat-bonded polyethylene and kraft paper] [2.5-mil-thick polysurlyn].**
 - d. Moisture Barrier for Outdoor Applications: **[3-mil-thick, heat-bonded polyethylene and kraft paper] [2.5-mil-thick polysurlyn].**
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- E. Underground Direct-Buried Jacket: 125-mil-thick vapor barrier and waterproofing membrane, consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- F. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with **[white] [stucco-embossed]** aluminum-foil facing.
 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- G. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested in accordance with ASTM E96/E96M and with a flame-spread index of 10 and a smoke-developed index of 20 when tested in accordance with ASTM E84.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

- H. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested in accordance with ASTM E96/E96M and with a flame-spread index of 25 and a smoke-developed index of 50 when tested in accordance with ASTM E84.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

- I. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2.11 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2. Width: [3-inches] <Insert value>.

3. Thickness: [11.5 mils] <Insert value>.

4. Adhesion: [90 ounces force/inch] <Insert value> in width.

5. Elongation: [2] <Insert number> percent.

6. Tensile Strength: [40 lbf/inch] <Insert value> in width.

7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2. Width: [3-inches] <Insert value>.

3. Thickness: [6.5 mils] <Insert value>.

4. Adhesion: [90 ounces force/inch] <Insert value> in width.

5. Elongation: [2] <Insert number> percent.

6. Tensile Strength: [40 lbf/inch] <Insert value> in width.

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7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Width: [**2-inches**] **<Insert value>**.
 3. Thickness: [**6 mils**] **<Insert value>**.
 4. Adhesion: [**64 ounces force/inch**] **<Insert value>** in width.
 5. Elongation: [**500**] **<Insert number>** percent.
 6. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Width: [**2-inches**] **<Insert value>**.
 3. Thickness: [**3.7 mils**] **<Insert value>**.
 4. Adhesion: [**100 ounces force/inch**] **<Insert value>** in width.
 5. Elongation: [**5**] **<Insert number>** percent.
 6. Tensile Strength: [**34 lbf/inch**] **<Insert value>** in width.
- E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Width: [**3-inches**] **<Insert value>**.
 3. Film Thickness: [**2 mils**] **<Insert value>**.
 4. Adhesive Thickness: [**1.5 mils**] **<Insert value>**.
 5. Elongation at Break: [**120**] **<Insert number>** percent.
 6. Tensile Strength: [**20 psi**] **<Insert value>** in width.
- F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Width: [**3-inches**] **<Insert value>**.
 3. Film Thickness: [**6 mils**] **<Insert value>**.
 4. Adhesive Thickness: [**1.5 mils**] **<Insert value>**.
 5. Elongation at Break: [**145**] **<Insert number>** percent.
 6. Tensile Strength: [**55 psi**] **<Insert value>** in width.

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2.12 SECUREMENTS

A. Bands:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Stainless Steel: ASTM A240/A240M, [Type 304] [or] [Type 316]; 0.015 inch thick, [1/2 inch] [3/4 inch] wide with [wing seal] [or] [closed seal].
3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, [1/2 inch] [3/4 inch] wide with [wing seal] [or] [closed seal].
4. Springs: Twin spring set constructed of stainless steel, with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.

C. Wire: [0.080-inch nickel-copper alloy] [0.062-inch soft-annealed, stainless steel] [0.062-inch soft-annealed, galvanized steel].

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140

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and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

- C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 1. Install insulation continuously through hangers and around anchor attachments.

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2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4-inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2-inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at **[2-inches] [4-inches]** o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 25 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least **[4-inches]** beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.

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3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2-inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2-inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

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3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 - 2. Insulate pipe elbows using **[preformed fitting insulation]** **[or]** **[mitered fittings]** made from same material and density as that of adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - 3. Insulate tee fittings with **[preformed fitting insulation]** **[or]** **[sectional pipe insulation]** of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 - 4. Insulate valves using **[preformed fitting insulation]** **[or]** **[sectional pipe insulation]** of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 - 5. Insulate strainers using **[preformed fitting insulation]** **[or]** **[sectional pipe insulation]** of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 - 6. Insulate flanges, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
 - 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

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8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers[**at locations indicated**]. Installation shall conform to the following:
 1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2-inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
 1. Secure single-layer insulation with stainless steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
 2. Install two-layer insulation with joints tightly butted and staggered at least 3-inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless steel bands at 12-inch intervals.
 3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1-inch. Apply finish coat of lagging

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adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as that of pipe insulation.
4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6-inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

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B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1-inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.

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2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as that of pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6-inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1-inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.

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2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.10 INSTALLATION OF PHENOLIC INSULATION

A. General Installation Requirements:

1. Secure single-layer insulation with stainless steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3-inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless steel bands at 12-inch intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6-inches o.c.
4. For insulation with factory-applied jackets with vapor retarders on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as that of pipe insulation.

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D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.11 INSTALLATION OF POLYISOCYANURATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, and same thickness as that of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as that of pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate insulation to valve body.

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2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.12 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.13 INSTALLATION OF POLYSTYRENE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

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1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, and make thickness same as that of adjacent pipe insulation, not to exceed 1-1/2-inch.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness that of as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed section of polystyrene insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.14 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.

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4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated and for horizontal applications, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12-inches o.c. and at end joints.
- E. Where PVDC jackets are indicated, install as follows:
1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
 2. Wrap factory-presizes jackets around individual pipe insulation sections, with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2-inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
 3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
 4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2-inches or less. The 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
 5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.15 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Flat Acrylic Finish: [Two] <Insert number> finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless steel jackets.

3.16 FIELD QUALITY CONTROL

- A. Owner will engage a qualified testing agency to perform tests and inspections.
- B. Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- E. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to [three] <Insert number> locations of straight pipe, [three] <Insert number> locations of threaded fittings, [three] <Insert number> locations of welded fittings, [two] <Insert number> locations of threaded strainers, [two] <Insert number> locations of welded strainers, [three] <Insert number> locations of threaded valves, and [three] <Insert number> locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- F. All insulation applications will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3.17 PIPING INSULATION SCHEDULE, GENERAL

- A. Insulation conductivity and thickness per pipe size shall comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.
- B. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- C. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Underground piping.
 - 2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.18 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate and Equipment Drain Water below 60 Deg F:
 - 1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [**1-1/2-inches**] **<Insert dimension>** thick.
 - b. Flexible Elastomeric: [**3/4-inch**] [**1-inch**] **<Insert dimension>** thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**1/2-inch**] [**1-inch**] **<Insert dimension>** thick.
 - d. Phenolic: [**1-inch**] **<Insert dimension>** thick.
 - e. Polyisocyanurate: [**1-inch**] **<Insert dimension>** thick.
 - f. Polyolefin: [**3/4-inch**] [**1-inch**] **<Insert dimension>** thick.
- B. Chilled Water and Brine, 40 Deg F and below:
 - 1. [**NPS 3**] **<Insert pipe size>** and Smaller: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [**1-1/2-inches**] [**2-inches**] **<Insert dimension>** thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**1-inch**] [**1-1/2-inches**] [**2-inches**] **<Insert dimension>** thick.
 - c. Phenolic: [**1-inch**] [**1-1/2-inches**] [**2-inches**] [**3-inches**] **<Insert dimension>** thick.
 - d. Polyisocyanurate: [**1-inch**] **<Insert dimension>** thick.
 - 1. [**NPS 4 to NPS 12**] **<Insert pipe size range>**: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [**1-1/2-inches**] [**2-inches**] [**3-inches**] **<Insert dimension>** thick.

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- b. Mineral-Fiber, Preformed Pipe Insulation, Type I: [1-1/2-inches] [2-inches] <Insert dimension> thick.
 - c. Phenolic: [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.
 - d. Polyisocyanurate: [1-inch] <Insert dimension> thick.
1. [NPS 14] <Insert pipe size> and Larger: Insulation shall be[one of] the following:
- a. Cellular Glass: [2-inches] [3-inches] <Insert dimension> thick.
 - b. Mineral-Fiber, [Preformed Pipe Insulation, Type I,] [or] [Pipe and Tank Insulation]: [2-inches] [3-inches] <Insert dimension> thick.
 - c. Phenolic: [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.

C. Chilled Water and Brine, Above 40 Deg F:

1. [NPS 12] <Insert pipe size> and Smaller: Insulation shall be[one of] the following:
- a. Cellular Glass: [1-1/2-inches] [2-inches] <Insert dimension> thick.
 - b. Flexible Elastomeric: [1-inch] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [1-inch] [1-1/2-inches] [2-inches] <Insert dimension> thick.
 - d. Phenolic: [1-inch] [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.
 - e. Polyisocyanurate: [1-inch] <Insert dimension> thick.
 - f. Polyolefin: [1-inch] <Insert dimension> thick.
1. [NPS 14] <Insert pipe size> and Larger: Insulation shall be[one of] the following:
- a. Cellular Glass: [2-inches] [3-inches] <Insert dimension> thick.
 - b. Mineral-Fiber [Preformed Pipe Insulation, Type I,] [or] [Pipe and Tank Insulation]: [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.
 - c. Phenolic: [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.

D. Condenser-Water Supply and Return:

1. [NPS 12] <Insert pipe size> and Smaller: Insulation shall be[one of] the following:
- a. Cellular Glass: [1-1/2-inches] [2-inches] <Insert dimension> thick.
 - b. Flexible Elastomeric: [1-inch] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [1-inch] [1-1/2-inches] [2-inches] <Insert dimension> thick.
 - d. Phenolic: [1-inch] [1-1/2-inches] <Insert dimension> thick.
 - e. Polyisocyanurate: [1-inch] <Insert dimension> thick.

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- f. Polyolefin: [1-inch] <Insert dimension> thick.
- 1. [NPS 14] <Insert pipe size> and Larger: Insulation shall be[one of] the following:
 - a. Cellular Glass: [2-inches] [3-inches] <Insert dimension> thick.
 - b. Mineral-Fiber, [Preformed Pipe Insulation, Type I] [or] [Pipe and Tank Insulation]: [1-1/2-inches] [2-inches] [3 -nches] <Insert dimension> thick.
 - c. Phenolic: [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.
- E. Heating-Hot-Water Supply and Return, 200 Deg F and Below:
 - 1. [NPS 12] <Insert pipe size> and Smaller: Insulation shall be[one of] the following:
 - a. Cellular Glass: [1-1/2-inches] [2-inches] <Insert dimension> thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: [1-inch] [2-inches] <Insert dimension> thick.
 - c. Phenolic: [1-inch] [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.
 - d. Polyisocyanurate: [1-inch] <Insert dimension> thick.
 - 1. [NPS 14] <Insert pipe size> and Larger: Insulation shall be[one of] the following:
 - a. Cellular Glass: [2-inches] [3-inches] <Insert dimension> thick.
 - b. Mineral-Fiber, [Preformed Pipe Insulation, Type I] [or] [Pipe and Tank Insulation]: [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.
 - c. Phenolic: [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.
- F. Heating-Hot-Water Supply and Return, Above 200 Deg F:
 - 1. [NPS 3/4] <Insert pipe size> and Smaller: Insulation shall be[one of] the following:
 - a. Calcium Silicate: [2-inches] [3-inches] <Insert dimension> thick.
 - b. Cellular Glass: [2-inches] [3-inches] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [1-1/2-inches] [2-inches] <Insert dimension> thick.
 - 1. [NPS 1] <Insert pipe size> and Larger: Insulation shall be[one of] the following:
 - a. Calcium Silicate: [3-inches] [4-inches] <Insert dimension> thick.
 - b. Cellular Glass: [3-inches] [4-inches] <Insert dimension> thick.

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- c. Mineral-Fiber, Preformed Pipe, Type I: [3-inches] [4-inches] <Insert dimension> thick.
- G. Steam and Steam Condensate, Boiler Blowdown, Vents, Drains[, and Safety Relief Vents] 350 Deg F and Below:
 - 1. [NPS 3/4] <Insert pipe size> and Smaller: Insulation shall be[one of] the following:
 - a. Calcium Silicate: [2-inches] [3-inches] <Insert dimension> thick.
 - b. Cellular Glass: [2-inches] [3-inches] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [1-1/2-inches] [2-inches] <Insert dimension> thick.
 - 1. [NPS 1] <Insert pipe size> and Larger: Insulation shall be[one of] the following:
 - a. Calcium Silicate: [3-inches] [4-inches] <Insert dimension> thick.
 - b. Cellular Glass: [3-inches] [4-inches] <Insert dimension> thick.
 - c. Mineral-Fiber, [Preformed Pipe Insulation, Type I] [or] [Pipe and Tank Insulation]: [3-inches] [4-inches] <Insert dimension> thick.
- H. Steam and Steam Condensate, Boiler Blowdown, Vents, Drains[, and Safety Relief Vents] Above 350 Deg F:
 - 1. [NPS 3/4] <Insert pipe size> and Smaller: Insulation shall be[one of] the following:
 - a. Calcium Silicate: [2-inches] [3-inches] <Insert dimension> thick.
 - b. Cellular Glass: [2-inches] [3-inches] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [1-1/2-inches] [2-inches] <Insert dimension> thick.
 - 1. [NPS 1] <Insert pipe size> and Larger: Insulation shall be[one of] the following:
 - a. Calcium Silicate: [3-inches] [4-inches] <Insert dimension> thick.
 - b. Cellular Glass: [3-inches] [4-inches] <Insert dimension> thick.
 - c. Mineral-Fiber, [Preformed Pipe Insulation, Type I] [or] [Pipe and Tank Insulation]: [3-inches] [4-inches] <Insert dimension> thick.
- I. Refrigerant Suction and Hot-Gas Piping:
 - 1. All Pipe Sizes: Insulation shall be[one of] the following:
 - a. Cellular Glass: [1-1/2-inches] <Insert dimension> thick.
 - b. Flexible Elastomeric: [1-inch] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [1-inch] <Insert dimension> thick.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- d. Phenolic: [1-inch] <Insert dimension> thick.
- e. Polyisocyanurate: [1-inch] <Insert dimension> thick.
- f. Polyolefin: [1-inch] <Insert dimension> thick.

J. Refrigerant Suction and Hot-Gas Flexible Tubing:

- 1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Flexible Elastomeric: [2-inches] <Insert dimension> thick.
 - b. Polyolefin: [2-inches] <Insert dimension> thick.

K. Refrigerant Liquid Piping:

- 1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [1-1/2-inches] <Insert dimension> thick.
 - b. Flexible Elastomeric: [1-inch] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [1-inch] <Insert dimension> thick.
 - d. Phenolic: [1-inch] <Insert dimension> thick.
 - e. Polyisocyanurate: [1-inch] <Insert dimension> thick.
 - f. Polyolefin: [1-inch] <Insert dimension> thick.

L. Dual-Service Heating and Cooling, 40 to 200 Deg F:

- 1. [NPS 12] <Insert pipe size> and Smaller: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [1-1/2-inches] [2-inches] <Insert dimension> thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: [1-inch] [1-1/2-inches] [2-inches] <Insert dimension> thick.
 - c. Phenolic: [1-inch] [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.
 - d. Polyisocyanurate: [1-inch] <Insert dimension> thick.
- 1. [NPS 14] <Insert pipe size> and Larger: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [2-inches] [3-inches] <Insert dimension> thick.
 - b. Mineral-Fiber, [Preformed Pipe Insulation, Type I] [or] [Pipe and Tank Insulation]: [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.
 - c. Phenolic: [1-1/2-inches] [2-inches] [3-inches] <Insert dimension> thick.

M. Heat-Recovery Piping:

- 1. All Pipe Sizes: Insulation shall be[**one of**] the following:

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- a. Cellular Glass: [1-1/2-inches] <Insert dimension> thick.
- b. Flexible Elastomeric: [1-inch] <Insert dimension> thick.
- c. Mineral-Fiber, [Preformed Pipe Insulation, Type I] [or] [Pipe and Tank Insulation]: [1-inch] <Insert dimension> thick.
- d. Phenolic: [1-inch] <Insert dimension> thick.
- e. Polyisocyanurate: [1-inch] <Insert dimension> thick.
- f. Polyolefin: [1-inch] <Insert dimension> thick.

3.19 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water and Brine:

- 1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [3-inches] <Insert dimension> thick.
 - b. Flexible Elastomeric: [3-inches] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [3-inches] <Insert dimension> thick.
 - d. Phenolic: [2-inches] <Insert dimension> thick.
 - e. Polyisocyanurate: [2-inches] <Insert dimension> thick.
 - f. Polyolefin: [3-inches] <Insert dimension> thick.
 - g. Polystyrene: [2-inches] <Insert dimension> thick.

B. Condenser-Water Supply and Return:

- 1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [2-inches] <Insert dimension> thick.
 - b. Flexible Elastomeric: [2-inches] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [2-inches] <Insert dimension> thick.
 - d. Phenolic: [2-inches] <Insert dimension> thick.
 - e. Polyisocyanurate: [2-inches] <Insert dimension> thick.
 - f. Polyolefin: [2-inches] <Insert dimension> thick.
 - g. Polystyrene: [2-inches] <Insert dimension> thick.

C. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

- 1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [3-inches] <Insert dimension> thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: [2-inches] <Insert dimension> thick.
 - c. Phenolic: [2-inches] <Insert dimension> thick.
 - d. Polyisocyanurate: [2-inches] <Insert dimension> thick.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

D. Heating-Hot-Water Supply and Return, Above 200 Deg F:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Calcium Silicate: [**3-inches**] <Insert dimension> thick.
 - b. Cellular Glass: [**3-inches**] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**2-inches**] <Insert dimension> thick.

E. Steam and Steam Condensate[, **and Safety Relief Vents**], 350 Deg F and Below:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Calcium Silicate: [**4-inches**] <Insert dimension> thick.
 - b. Cellular Glass: [**4-inches**] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**3-inches**] <Insert dimension> thick.

F. Steam and Steam Condensate[, **and Safety Relief Vents**], Above 350 Deg F:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Calcium Silicate: [**5-inches**] <Insert dimension> thick.
 - b. Cellular Glass: [**5-inches**] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**4-inches**] <Insert dimension> thick.

G. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [**2-inches**] <Insert dimension> thick.
 - b. Flexible Elastomeric: [**2-inches**] <Insert dimension> thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**2 inches**] <Insert dimension> thick.
 - d. Phenolic: [**2-inches**] <Insert dimension> thick.
 - e. Polyisocyanurate: [**2-inches**] <Insert dimension> thick.
 - f. Polyolefin: [**2-inches**] <Insert dimension> thick.
 - g. Polystyrene: [**2-inches**] <Insert dimension> thick.

H. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Flexible Elastomeric: [**2-inches**] <Insert dimension> thick.
 - b. Polyolefin: [**2-inches**] <Insert dimension> thick.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

I. Refrigerant Liquid Piping:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Flexible Elastomeric: [**1-inch**] [**2-inches**] **<Insert dimension>** thick.
 - b. Polyolefin: [**1-inch**] [**2-inches**] **<Insert dimension>** thick.

J. Heat-Recovery Piping:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [**2-inches**] **<Insert dimension>** thick.
 - b. Flexible Elastomeric: [**2-inches**] **<Insert dimension>** thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**2-inches**] **<Insert dimension>** thick.
 - d. Phenolic: [**2-inches**] **<Insert dimension>** thick.
 - e. Polyisocyanurate: [**2-inches**] **<Insert dimension>** thick.
 - f. Polyolefin: [**2-inches**] **<Insert dimension>** thick.
 - g. Polystyrene: [**2-inches**] **<Insert dimension>** thick.

K. Dual-Service Heating and Cooling:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [**3-inches**] **<Insert dimension>** thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**2-inches**] **<Insert dimension>** thick.
 - c. Phenolic: [**2-inches**] **<Insert dimension>** thick.
 - d. Polyisocyanurate: [**2-inches**] **<Insert dimension>** thick.

L. Fuel Oil Piping, Heated:

1. All Pipe Sizes: Insulation shall be[**one of**] the following:
 - a. Cellular Glass: [**2-inches**] **<Insert dimension>** thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: [**2-inches**] **<Insert dimension>** thick.

3.20 OUTDOOR, UNDERGROUND, PIPING INSULATION SCHEDULE

- A. Insulation, for belowground piping, is specified in Section 23 21 13.13 "Underground Hydronic Piping" and Section 33 63 13 "Underground Steam and Condensate Distribution Piping."
- B. Chilled Water, All Sizes: Cellular glass, [**2-inches**] **<Insert dimension>** thick.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- C. Condenser-Water Supply and Return, All Sizes: Cellular glass, [2-inches] <Insert dimension> thick.
- D. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F and Below: Cellular glass, [3-inches] <Insert dimension> thick.
- E. Heating-Hot-Water Supply and Return, All Sizes, Above 200 Deg F:
 - 1. Calcium Silicate: [3-inches] <Insert dimension> thick.
 - 2. Cellular Glass: [3-inches] <Insert dimension> thick.
- F. Steam and Steam Condensate, All Sizes, 350 Deg F and Below:
 - 1. Calcium Silicate: [4-inches] <Insert dimension> thick.
 - 2. Cellular Glass: [4-inches] <Insert dimension> thick.
- G. Steam and Steam Condensate, All Sizes, Above 350 Deg F:
 - 1. Calcium Silicate: [5-inches] <Insert dimension> thick.
 - 2. Cellular Glass: [5-inches] <Insert dimension> thick.
- H. Dual-Service Heating and Cooling, All Sizes, 40 to 200 Deg F: Cellular glass, [3-inches] <Insert dimension> thick.
- I. Fuel Oil Piping, All Sizes, Heated: Cellular glass, [2-inches] <Insert dimension> thick.

3.21 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 - 1. None.
 - 2. [PVC] [PVC, Color-Coded by System]: [20 mils] [30 mils] thick.
 - 3. Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016-inch] [0.020-inch] [0.024-inch] [0.032-inch] [0.040-inch] thick.
 - 4. Painted Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016-inch] [0.020-inch] [0.024 -inch] [0.032 inch] thick.
 - 5. Stainless Steel, [Type 304] [or] [Type 316], [Smooth No. 2B Finish] [Corrugated] [Stucco Embossed]: [0.010-inch] [0.016-inch] [0.020-inch] [0.024-inch] thick.
 - 6. <Insert jacket type>.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

D. Piping, Exposed:

1. None.
2. [PVC] [PVC, Color-Coded by System]: [20 mils] [30 mils] thick.
3. Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016-inch] [0.020-inch] [0.024-inch] [0.032-inch] [0.040-inch] thick.
4. Painted Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016-inch] [0.020-inch] [0.024-inch] [0.032-inch] thick.
5. Stainless Steel, [Type 304] [or] [Type 316], [Smooth No. 2B Finish] [Corrugated] [Stucco Embossed]: [0.010-inch] [0.016-inch] [0.020-inch] [0.024 -nch] thick.
6. <Insert jacket type>.

3.22 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:

1. None.
2. [PVC] [PVC, Color-Coded by System]: [20 mils] [30 mils] thick.
3. Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016-inch] [0.020-inch] [0.024-inch] [0.032-inch] [0.040-inch] thick.
4. Painted Aluminum, [Smooth] [Corrugated] [Stucco Embossed]: [0.016-inch] [0.020-inch] [0.024-inch] [0.032-inch] thick.
5. Stainless Steel, [Type 304] [Type 316] [Type 304] [or] [Type 316], [Smooth No. 2B Finish] [Corrugated] [Stucco Embossed]: [0.010-inch] [0.016-inch] [0.020-inch] [0.024-inch] thick.
6. <Insert jacket type>.

D. Piping, Exposed:

1. PVC: [20 mils] [30 mils] [40 mils] thick.
2. [Painted]Aluminum, [Smooth] [Corrugated] [Stucco Embossed] [with Z-Shaped Locking Seam]: [0.016-inch] [0.020-inch] [0.024-inch] [0.032 -nch] [0.040-inch] thick.
3. Stainless Steel, [Type 304] [Type 316] [Type 304] [or] [Type 316], [Smooth No. 2B Finish] [Corrugated] [Stucco Embossed] [with Z-Shaped Locking Seam]: [0.010-inch] [0.016-inch] [0.020-inch] [0.024-inch] thick.
4. <Insert jacket type>.

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3.23 UNDERGROUND, FIELD-APPLIED INSULATION JACKET

- A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION

SECTION 23 08 00

COMMISSIONING OF HVAC
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

- B. Related Sections:

Section 01 91 13 – GENERAL COMMISSIONING REQUIREMENTS

Section 23 05 33 – HEAT TRACING FOR HVAC PIPING

[Section 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT]

[Section 23 05 48.13 – VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT]

Section 23 05 93 – TESTING, ADJUSTING, AND BALANCING FOR HVAC

1.3 SUMMARY:

- A. Section includes Cx process requirements for the following HVAC systems, assemblies, and equipment:

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1. Energy supply systems.
2. Heat generation systems.
3. Cooling generation systems.
4. Central-station air-handling systems.
5. Air, steam, and hydronic distribution systems.
6. Heating and cooling terminal and unitary equipment.
7. HVAC controls.
8. TAB verification.

1.4 DEFINITIONS:

- A. BAS: Building automation system.
- B. Cx: Commissioning, as defined in Section 01 91 13 – GENERAL COMMISSIONING REQUIREMENTS.
- C. CxA: Commissioning Authority, as defined in Section 01 91 13 - GENERAL COMMISSIONING REQUIREMENTS.
- D. DDC: Direct digital controls.
- E. HVAC: Heating, ventilating, and air conditioning.
- F. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.
- G. TAB: Testing, adjusting, and balancing.

1.5 INFORMATIONAL SUBMITTALS:

- A. Qualification Data: For **[BAS]** **[and]** **[HVAC]** Testing Technician.
- B. Construction Checklists: Draft construction checklists will be created by CxA for Contractor review.
- C. Construction Checklists: Material, installation, and performance test checklists for systems, assemblies, subsystems, equipment, and components to be part of the Cx process and according to requirements in Section 01 91 13 – GENERAL COMMISSIONING REQUIREMENTS.
 1. Instrumentation and control for HVAC, including the following:
 - a. Control systems equipment.
 - b. Control valves.
 - c. Control dampers.
 - d. Energy meters.

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- e. Flow instruments.
 - f. Gas instruments.
 - g. Level instruments.
 - h. Leak-detection instruments.
 - i. Moisture instruments.
 - j. Motion instruments.
 - k. Position instruments.
 - l. Pressure instruments.
 - m. Speed instruments.
 - n. Temperature instruments.
 - o. Vibration instruments.
 - p. Weather stations.
 - q. Sequence of operations.
2. Fuel piping, including the following:
- a. [Natural gas] [liquid-petroleum gas] [and] [fuel-oil] piping, fittings, and specialties.
 - b. Fuel-oil pumps and motors.
 - c. Sleeves and sleeve seals.
 - d. Meters and gages.
 - e. General-duty and specialty valves.
 - f. Hangers and supports.
 - g. Heat tracing.
 - h. Vibration isolation [**and seismic restraints**].
3. Hydronic piping, including the following:
- a. Heating hot-water, chilled-water, and condenser-water piping, fittings, and specialties.
 - b. Hydronic pumps and motors.
 - c. Sleeves and sleeve seals.
 - d. Meters and gages.
 - e. General-duty and specialty valves.
 - f. Hangers and supports.
 - g. Heat tracing.
 - h. Vibration isolation [**and seismic restraints**].
4. Steam and condensate piping, including the following:
- a. Steam and condensate piping, fittings, and specialties.
 - b. Steam condensate pumps, motors, controls, and accessories.
 - c. Sleeves and sleeve seals.
 - d. Meters and gages.
 - e. General-duty and specialty valves.
 - f. Hangers and supports.
 - g. Vibration isolation [**and seismic restraints**].

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5. Refrigerant piping, including the following:
 - a. Refrigerant piping, fittings, and specialties.
 - b. Refrigerant charge.
 - c. Sleeves and sleeve seals.
 - d. Meters and gages.
 - e. General-duty and specialty valves.
 - f. Hangers and supports.
 - g. Vibration isolation [**and seismic restraints**].
6. Air distribution systems, including the following:
 - a. Supply, return, and exhaust systems.
 - b. Metal ducts, liners, and fittings.
 - c. Nonmetal ducts and fittings.
 - d. Hangers and supports.
 - e. Vibration isolation [**and seismic restraints**].
 - f. Flexible ducts and fittings.
 - g. Air-duct accessories, including volume dampers, fire and smoke dampers, turning vanes, sound attenuators, and flexible connectors.
 - h. Duct-mounted access doors and panels.
7. Air-handling equipment, including the following:
 - a. Fans and motors.
 - b. Indoor air-handling units with and without coils, dampers, and filters.
 - c. Outdoor air-handling units with and without coils, dampers, and filters.
 - d. Motors.
 - e. Hangers and supports.
 - f. Vibration isolation [**and seismic restraints**].
8. Air-filtration equipment, including mounting and support and for the following:
 - a. Particulate air filters.
 - b. Gas-phase air filters.
 - c. Electronic air cleaners.
9. Computer-room air conditioners.
10. Boilers, including the following:
 - a. Supports and restraints.
 - b. Trim, accessories, and factory-installed controls.
 - c. Breechings, chimneys, and stacks.
 - d. Feedwater equipment.
 - e. Deaerators.
11. Chillers, including the following:

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- a. Supports and restraints.
 - b. Trim, accessories, and factory-installed controls.
 - c. Motors.
- 12. Cooling towers, including the following:
 - a. Supports and restraints.
 - b. Trim, accessories, and factory-installed controls.
 - c. Sump pumps, motors, controls, and accessories.
 - d. Fans, motors, controls, and accessories.
- 13. Mechanical insulation, including the following:
 - a. Duct and plenum insulation.
 - b. Fire-suppression, plumbing, and HVAC equipment insulation.
 - c. Plumbing and HVAC piping insulation.
- D. Test equipment and instrumentation list, identifying the following:
 - 1. Equipment/instrument identification number.
 - 2. Planned Cx application or use.
 - 3. Manufacturer, make, model, and serial number.
 - 4. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
 - 5. Equipment manufacturers' proprietary instrumentation and tools. For each instrument or tool, identify the following:
 - a. Instrument or tool identification number.
 - b. Equipment schedule designation of equipment for which the instrument or tool is required.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

1.6 QUALITY ASSURANCE:

- A. BAS Testing Technician Qualifications: Technicians to perform BAS construction checklist verification tests, construction checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
 - 1. Journey level or equivalent skill level with knowledge of BAS, HVAC, electrical concepts, and building operations.
 - 2. Minimum [**three years'**] **<Insert time>** experience installing, servicing, and operating systems manufactured by approved manufacturer.
 - 3. International Society of Automation (ISA)-Certified Control Systems Technician (CCST) Level I.

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- B. HVAC Testing Technician Qualifications: Technicians to perform HVAC construction checklist verification tests, construction checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
1. Journey level or equivalent skill level. Vocational school four-year-program graduate or an associate degree in mechanical systems, air conditioning, or similar field. Degree may be offset by three years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC equipment, assemblies, and systems.
 2. Minimum [**three years'**] **<Insert time>** experience installing, servicing, and operating systems manufactured by approved manufacturer.
- C. Testing Equipment and Instrumentation Quality and Calibration:
1. Capable of testing and measuring performance within the specified acceptance criteria.
 2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 3. Be maintained in good repair and operating condition throughout duration of use on Project.
 4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.
- D. Proprietary Test Instrumentation and Tools:
1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:
 - a. Be calibrated by manufacturer with current calibration tags permanently affixed.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 - c. HVAC proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

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PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLISTS:

A. Prepare detailed construction checklists for following HVAC systems, assemblies, subsystems, equipment, and components:

1. Energy supply systems, including the following:
 - a. Fuel-oil supply.
 - b. Fuel gas supply.
 - c. Central-plant steam supply.
 - d. Central-plant hot-water supply.
 - e. Solar-energy supply.
 - f. **<Insert supply sources>.**
2. Heat generation systems, including the following:
 - a. Boilers.
 - b. Furnaces.
 - c. Fuel-fired unit heaters.
 - d. Auxiliary equipment.
 - e. **<Insert equipment>.**
3. Cooling generation systems, including the following:
 - a. Water chillers.
 - b. Cooling towers.
 - c. Direct-expansion refrigeration systems.
 - d. **<Insert systems>.**
4. Central-station air-handling systems.
5. Air, steam, and hydronic distribution systems, including the following:
 - a. Supply, return, outdoor-air, and exhaust-air distribution systems.
 - b. Steam distribution systems.
 - c. Hydronic systems.
 - d. **<Insert systems>.**
6. Heating and cooling terminal and unitary equipment, including the following:
 - a. Unit ventilators.
 - b. Unit heaters.
 - c. Fan-coil units.

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- d. Finned-tube radiation.
 - e. Electric heating.
 - f. Unitary heating and cooling equipment.
 - g. **<Insert units>**.
- 7. Controls and instrumentation.
 - 8. TAB verification.

3.2 CONSTRUCTION CHECKLIST REVIEW:

- A. Review and provide written comments on draft construction checklists. CxA will create required draft construction checklists and provide them to Contractor.
- B. Return draft construction checklist review comments within [10] **<Insert number>** days of receipt.
- C. When review comments have been resolved, the CxA will provide final construction checklists, marked "Approved for Use, (date)."
- D. Use only construction checklists, marked "Approved for Use, (date)."

3.3 Cx TESTING PREPARATION:

- A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved submittals.
- B. Certify that HVAC instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved submittals, and that pretest set points have been recorded.
- C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.4 Cx TEST CONDITIONS:

- A. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA and document

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simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.

2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- B. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.
- C. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.5 Cx TESTS COMMON TO HVAC SYSTEMS:

- A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.
- B. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response according to acceptance criteria.
- C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.
- D. Comply with construction checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Division 23 Sections specifying HVAC systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
1. Construction checklist verification tests.
 2. Construction checklist verification test demonstrations.
 3. Cx tests.
 4. Cx test demonstrations.
- F. Vibration Isolation in HVAC Systems:
1. Prerequisites: Acceptance of results of construction checklists for vibration [**and seismic**] control devices specified in [**Section 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.**] [**Section 23 05 48.13 – VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT.**]
 2. Components to Be Tested:

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- a. Vibration isolation [**and seismic**] control devices in HVAC systems.
- b. Structural systems.
3. Test Purpose: Evaluate effectiveness of vibration isolation [**and seismic**] control devices.
4. Test Conditions: Measure vibration of the facility structure at [**three**] **<Insert number>** locations designated by Owner's witness while the isolated equipment operates.
5. Test Conditions: Measure vibration of the facility structure at [**three**] **<Insert number>** locations designated by Owner's witness at the following operating conditions:
 - a. Maximum speed.
 - b. Minimum speed.
 - c. Critical speed.
6. Acceptance Criteria: Structure-borne vibration not to exceed specified performance.

G. Heat Tracing in HVAC Systems:

1. Prerequisites: Acceptance of results of construction checklists for heat tracing specified in HVAC systems. Comply with requirements listed in Section 23 05 33 – HEAT TRACING FOR HVAC PIPING.
2. Equipment and Systems to Be Tested:
 - a. Self-regulating, parallel-resistance heating cables.
 - b. Heater trace circuit controller.
3. Test Purpose:
 - a. Evaluate response to ambient temperature below freeze-protection set point.
 - b. Evaluate heating cable fault alarm.
4. Test Conditions:
 - a. Subject temperature sensor to temperature approximately [**3 deg F**] **<Insert value>** above freeze-protection set point (initial set point [**41 deg F**] **<Insert value>**). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is energized.
 - b. Subject temperature sensor to temperature approximately [**3 deg F**] **<Insert value>** below freeze-protection set point (initial set point [**41 deg F**] **<Insert value>**). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is de-energized.
 - c. Simulate an electrical fault on the heating cable.

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5. Acceptance Criteria:

- a. Freeze-protection circuit is energized at set-point temperature minus 2 deg F.
- b. Freeze-protection circuit is de-energized at set-point temperature plus 2 deg F.
- c. Heater trace circuit controller initiates an alarm of cable fault. Alarm is correctly reported at the fire-alarm control panel.

3.6 TAB VERIFICATION:

- A. Prerequisites: Completion of "Examination" Article requirements and correction of deficiencies, as specified in Section 23 05 93 – TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- B. Completion of "Preparation" Article requirements for preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 23 05 93 – TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- C. Scope: HVAC air systems and hydronic piping systems.
- D. Purpose: Differential flow relationships intended to maintain air pressurization differentials between the various areas of Project.
- E. Conditions of the Test:
 1. Cx Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC.
 2. Systems operating in full heating mode [**with minimum outside-air volume**].
 3. Systems operating in full cooling mode [**with minimum outside-air volume**].
 4. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.
- F. Acceptance Criteria:
 1. Under all conditions, rechecked measurements comply with "Inspections" Article in Section 23 05 93 – TESTING, ADJUSTING, AND BALANCING FOR HVAC.
 2. Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than two times the tolerances allowed.
 3. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

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3.7 HEATING CONTROL SYSTEM Cx TESTS:

A. Heating-Water Supply Temperature Control:

1. Prerequisites: Installation verification of the following:
 - a. Startup of [boiler] <Insert boiler designation> [steam to hot-water converter] <Insert converter designation> <Insert prime heating-water equipment>.
 - b. Startup of heating-water pump(s) <Insert pump designation(s)>.
 - c. TAB of heating-water flow and pressure.
 - d. Input Device: Heating-water supply temperature; [thermostat] [thermistor temperature sensor] [resistance temperature sensor] <Insert device designation>.
 - e. Output Device: Control valve <Insert device designation>.
 - f. Display the following at the operator's workstation:
 - 1) Heating-water supply temperature.
 - 2) Heating-water supply temperature set point.
 - 3) Control-valve position.
2. Scope: Heating-water system.
3. Purpose: Control of heating-water supply temperature at input device <Insert device designation>.
4. Conditions of the Test:
 - a. Minimum heating-water flow.
 - b. Midrange Heating-Water Flow: [50 to 60] <Insert number(s)> percent of maximum.
 - c. Maximum heating-water flow.
5. Acceptance Criteria: Under all conditions, heating-water supply temperature is within plus or minus [2.0 deg F] <Insert temperature> of set point.

B. Heating-Water Supply Temperature Reset:

1. Prerequisites: Installation verification of the following:
 - a. Startup of [boiler] <Insert boiler designation> [steam to hot-water converter] <Insert converter designation> <Insert prime heating-water equipment>.
 - b. Startup of heating-water pump(s) <Insert pump designation(s)>.
 - c. TAB of heating-water flow and pressure.
 - d. Input Device: Heating-water supply temperature; [thermostat] [thermistor temperature sensor] [resistance temperature sensor] <Insert device designation>.
 - e. Input Device: Outdoor-air temperature; [electric, outdoor-air-reset controller] [outdoor-air sensor].

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- f. Output Device: Control valve <**Insert device designation**>.
 - g. Display the following at the operator's workstation:
 - 1) Outdoor-air temperature.
 - 2) Heating-water supply temperature.
 - 3) Heating-water supply temperature set point.
 - 4) Control-valve position.
2. Scope: Heating-water system.
3. Purpose: Control of heating-water supply temperature at heating-water supply temperature input device <**Insert device designation**> in response to variable outdoor-air temperature input; [**electric, outdoor-air-reset controller**] [**outdoor-air sensor**].
4. Conditions of the Test: Outdoor-air temperature input value may be overridden for this test.
- a. Low Temperature: Outdoor-air temperature between [**minus 30 and 0 deg F**] <**Insert temperature range**>.
 - b. Midrange Temperature: Outdoor-air temperature between [**30 and 45 deg F**] <**Insert temperature range**>.
 - c. High Temperature: Outdoor-air temperature above [**65 deg F**] <**Insert temperature**>.
5. Acceptance Criteria: Heating-water supply temperature resets in straight-line relationship with outdoor-air temperature for the following reset schedule. Under all conditions, heating-water supply temperature is within [**2.0 deg F**] <**Insert temperature**> of set point.
- a. [**195 deg F**] <**Insert temperature**> heating water when outdoor-air temperature is [**minus 30 deg F**] <**Insert temperature**>.
 - b. [**130 deg F**] <**Insert temperature**> heating water when outdoor-air temperature is [**65 deg F**] <**Insert temperature**>.
 - c. Under all conditions, heating-water supply temperature is within plus or minus [**2.0 deg F**] <**Insert temperature**> of set point.
- C. Control Primary Circulating Pump(s):
1. Prerequisites: Installation verification of the following:
- a. Startup of heating-water pump(s) <**Insert pump designation(s)**>.
 - b. Input Device: Outdoor-air temperature; [**electric, outdoor-air-reset controller**] [**outdoor-air sensor**].
 - c. Output Device: Heating-water pump; [**starter**] [**DDC system command to starter**] relay.
 - d. Display the following at the operator's workstation:
 - 1) Outdoor-air temperature.
 - 2) Operating status of primary circulating pump(s).

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2. Scope: Heating-water pump(s) <Insert pump designation(s)> and associated controls.
3. Purpose: On-off control of heating-water pump(s) in response to variable outdoor-air temperature input; [electric, outdoor-air-reset controller] [outdoor-air sensor].
4. Conditions of the Test:
 - a. High Temperature: Outdoor-air temperature above [65 deg F] <Insert temperature>.
 - b. Low Temperature: Outdoor-air temperature below [65 deg F] <Insert temperature>.
5. Acceptance Criteria:
 - a. High Temperature: Pump(s) are off when outside-air temperature is above [65 deg F] <Insert temperature>.
 - b. Low Temperature: Pump(s) are on when outside-air temperature is below [65 deg F] <Insert temperature>.

3.8 CENTRAL REFRIGERATION SYSTEM Cx TESTS:

A. Start and Stop Condenser-Water Pump(s):

1. Prerequisites: Installation verification of the following:
 - a. Startup of condenser-water pump(s) <Insert pump designation(s)>.
 - b. Startup of cooling tower <Insert cooling tower designation>.
 - c. Input Device: Water pressure transducer <Insert device designation>.
 - d. Input Device: [Space thermostat] [DDC system outdoor-air temperature] <Insert device designation>.
 - e. Input Device: [Time clock] [DDC system time schedule] <Insert device designation>.
 - f. Output Device: Hard wired through motor starter; [DDC system binary output] <Insert device designation>.
 - g. Output Device: [Time clock] [Binary output] <Insert device designation>.
 - h. Display the following at the operator's workstation:
 - 1) Low-level cooling-tower sump alarm.
 - 2) Outdoor-air temperature.
 - 3) Cooling (software) demand indication.
 - 4) Time and time schedule.
 - 5) Condenser-water pump(s) on-off status.
 - 6) Condenser-water pump(s) on-off indication.
 - 7) Condenser-water flow indication.
2. Scope:

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- a. Condenser-water system, including condenser-water pump(s), cooling towers, and associated controls.
3. Purpose:
 - a. Condenser-water pump(s) lockout.
 - b. Condenser-water pump(s) start.
 - c. Condenser-water pump(s) shutdown.
 - d. Low-level cooling-tower sump alarm.
 - e. Condenser-water pump(s) time-of-day schedule.
4. Conditions of the Test:
 - a. Verify Lockout: Start with condenser-water pump enable-input devices in the "disable" state to prevent pump start. One by one, place the enable-input devices in the "enable" state, and then return each to the "disable" state before placing the next enable-input device to the "enable" state.
 - b. Verify Start: Start with condenser-water pump enable-input devices in the "disable" state to prevent pump start. One by one, place the enable-input devices in the "enable" state.
 - c. Verify Shutdown: Place all enable-input devices in the "enable" state to allow the pump(s) to start. One by one, place the enable-input devices in the "disable" state, and then return each to the "enable" state before placing the next enable-input device to the "disable" state.
 - d. Verify Schedule: Compare condenser-water pump start and stop schedule times with Owner-approved time-of-day schedule.
5. Acceptance Criteria:
 - a. Lockout: No single enable-input device starts the pump(s) when released to the "enable" state.
 - b. Start: Condenser-water pump(s) start when, and only when, all enable-input devices are in the "enable" state.
 - c. Shutdown: Each enable-input device stops the condenser-water pump(s) when placed in the "disable" state, regardless of the state of other enable-input devices.
 - d. Schedule: Condenser-water pump start and stop schedule times agree with Owner-approved time-of-day schedule.
- B. Start and Stop Chilled-Water Pump(s):
 1. Prerequisites: Installation verification of the following:
 - a. Startup of chilled-water pump(s) **<Insert pump designation(s)>**.
 - b. Startup of condenser-water pump(s) **<Insert pump designation(s)>**.
 - c. Startup of cooling tower **<Insert cooling tower designation>**.
 - d. Input Device: Flow switch in condenser-water circuit**<Insert device designation>**.

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- e. Output Device: [**Starter**] [**DDC system command to starter**] relay.
- f. Display of the following at the operator's workstation:
 - 1) Chilled-water flow indication.
 - 2) Condenser-water flow indication.
 - 3) Chilled-water pump(s) on-off status.
 - 4) Chilled-water pump(s) on-off indication.
- 2. Scope: Chilled-water system, including chilled-water pump(s), associated controls, and condenser-water system controls.
- 3. Purpose:
 - a. Chilled-water pump(s) start.
 - b. Chilled-water pump(s) shutdown.
- 4. Conditions of the Test:
 - a. Verify Start: Start with chilled-water pump enable-input device in the "disable" state to prevent pump start. Place the enable-input device in the "enable" state.
 - b. Verify Shutdown: Start with the enable-input device in the "enable" state to allow the pump(s) to run. Then place the enable-input device in the "disable" state.
- 5. Acceptance Criteria:
 - a. Start: Chilled-water pump(s) start when, and only when, the enable-input device is in the "enable" state.
 - b. Shutdown: The enable-input device stops the chilled-water pump(s) when placed in the "disable" state.
- C. Start and Stop Cooling-Tower Fans(s):
 - 1. Prerequisites: Installation verification of the following:
 - a. Input Device: Flow switch in condenser-water circuit <**Insert device designation**>.
 - b. Output Device: [**Starter**] [**DDC system command to starter**] relay.
 - c. Display:
 - 1) Condenser-water flow indication.
 - 2) Cooling-tower fan(s) on-off indication.
 - 2. Scope: Condenser-water system, including cooling tower, condenser-water pump(s), and associated controls.
 - 3. Purpose:
 - a. Cooling-tower fan(s) start.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- b. Cooling-tower fan(s) shutdown.
- 4. Conditions of the Test:
 - a. Verify Start: Start with cooling-tower fan enable-input device in the "disable" state to prevent fan(s) start. Place the enable-input device in the "enable" state.
 - b. Verify Shutdown: Start with the enable-input device in the "enable" state to allow the fan(s) to run. Then place the enable-input device in the "disable" state.
- 5. Acceptance Criteria:
 - a. Start: Chilled-water pump(s) start when, and only when, the enable-input device is in the "enable" state.
 - b. Shutdown: The enable-input device stops the chilled-water pump(s) when placed in the "disable" state.
- D. Alternative Chiller(s):
 - 1. Prerequisites: Installation verification of the following:
 - a. Input Device: **[Electric alternator] [DDC system software] <Insert device designation>**.
 - b. Output Device: **[Chiller] [DDC system command to chiller] <Insert device designation>** terminal strip.
 - c. Display:
 - 1) Chiller(s) on-off indication.
 - 2) Chiller failure alarm.
 - 2. Scope:
 - a. Chilled-water system and associated controls.
 - b. Condenser-water system and associated controls.
 - 3. Purpose:
 - a. Lead-lag rotation of chillers.
 - b. Replacement of failed chiller in rotation.
 - c. Adding and dropping chillers as follows: **<Insert sequence and parameters>**.
 - d. Replacement of failed chiller in add/drop sequence.
 - e. Chiller failure alarm initiation.
 - 4. Conditions of the Test:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Lead-Lag Rotation - Chiller Start: Create a number of chilled-water system start-stop cycles equal to the number of chillers plus one.
- b. Lead-Lag Rotation - Lead Chiller Fail: Disable the lead chiller while it is running.
- c. Lead-Lag Rotation - Lag Chiller Fail: Disable a lag chiller while it is running.
- d. Lead-Lag Rotation - Chiller Start Fail: Disable a chiller while it is in standby mode. Initiate a lead-lag rotation call for the disabled chiller to start.
- e. Add/Drop Sequence - Increasing Demand: Increase chilled-water demand incrementally to observe the corresponding addition of chillers. Increase demand gradually as the load approaches the set point for adding the next chiller, to permit observation of the actual load at the time the next chiller is enabled.
- f. Add/Drop Sequence - Decreasing Demand: Decrease chilled-water demand incrementally to observe the corresponding dropping of chillers. Decrease demand gradually as the load approaches the set point for dropping the next chiller, to permit observation of the actual load at the time the next chiller is disabled.

5. Acceptance Criteria:

- a. Lead-Lag Rotation - Chiller Start: On each chilled-water system start event, the [other] [next] chiller in rotation starts as the lead chiller, and the previous lead chiller is designated as the [last] lag chiller.
- b. Lead-Lag Rotation - Lead Chiller Fail: When the lead chiller fails, the [other] [next] chiller in rotation starts as the lead chiller, and a chiller failure alarm is initiated for the failed chiller.
- c. Lead-Lag Rotation - Lag Chiller Fail: When the lag chiller fails, **[the next chiller in rotation starts as the lead chiller, and]** a chiller failure alarm is initiated for the failed chiller.
- d. Lead-Lag Rotation - Chiller Start Fail: When a chiller fails to start, **[the next chiller in rotation starts in its place, and]** a chiller failure alarm is initiated for the failed chiller.
- e. Add/Drop Sequence - Increasing Demand: Chillers are added at the specified load set point, plus or minus [5] <Insert number> percent. Chilled-water supply temperature remains stable within plus or minus [2.0 deg F] <Insert temperature> of set point.
- f. Add/Drop Sequence - Decreasing Demand: Chillers are dropped at the specified load set point, plus or minus [5] <Insert number> percent. Chilled-water supply temperature remains stable within plus or minus [2.0 deg F] <Insert temperature> of set point.
- g. Add/Drop Sequence - Operating Chiller Fail: When an operating chiller fails, the next chiller in sequence starts and a chiller failure alarm is initiated for the failed chiller.

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- h. Add/Drop Sequence - Chiller Start Fail: When a chiller fails to start, the next chiller in sequence starts in its place and a chiller failure alarm is initiated for the failed chiller.

3.9 TERMINAL UNIT EQUIPMENT Cx TESTS:

A. VAV Terminal Air Units with Coils:

1. Prerequisites: Installation verification of the following:
 - a. Occupancy Input Device: Occupancy sensor.
 - b. Occupancy Output Device: DDC system binary output.
 - c. Room Temperature Input Device: [**Room thermostat**] [**Electronic temperature sensor**].
 - d. Room Temperature Output Device: [**Pneumatic**] [**Electronic**] damper actuators and control-valve operators.
 - e. Display the following at the operator's workstation:
 - 1) Room/area served.
 - 2) Room occupied/unoccupied.
 - 3) Room temperature indication.
 - 4) Room temperature set point.
 - 5) Room temperature set point, occupied.
 - 6) Room temperature set point, unoccupied.
 - 7) Air-damper position as percentage open.
 - 8) Control-valve position as percentage open.
2. Scope: VAV terminal air units with [**hydraulic**] [**steam**] coils in supply-air systems, and associated controls.
3. Purpose:
 - a. Occupancy-dependent room temperature set-point reset.
 - b. Room temperature control.
4. Conditions of the Test:
 - a. Cx Test Demonstration Sampling Rate: [**10**] **<Insert number>** percent of each model/size unit.
 - b. Temperature Control - Occupied: Start with the room unoccupied. Occupy the room and observe the change to occupied status. Observe temperature control until room temperature is stable at occupied set point, plus or minus [**1.0 deg F**] **<Insert temperature>**.
 - c. Temperature Control - Unoccupied: Start with the room occupied. Vacate the room and observe the change to unoccupied status. Observe temperature control until room temperature is stable at unoccupied set point, plus or minus [**1.0 deg F**] **<Insert temperature>**.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

5. Acceptance Criteria:

a. Temperature Control - Occupied:

- 1) Control system status changes from "occupied" to "unoccupied" after the specified time.
- 2) Room temperature is stable at occupied set point, plus or minus [**1.0 deg F**] <Insert temperature> within [**10**] <Insert number> minutes of occupancy. Room temperature does not overshoot or undershoot set point by more than [**2.0 deg F**] <Insert temperature> during transition.

b. Temperature Control - Unoccupied:

- 1) Control system status changes from "unoccupied" to "occupied" [**immediately**] [**after five minutes of continuous occupancy**].
- 2) Room temperature is stable at unoccupied set point, plus or minus [**1.0 deg F**] <Insert temperature> within [**30**] <Insert number> minutes of occupancy.

3.10 AIR-HANDLING SYSTEM Cx TESTS:

A. Supply Fan(s) Variable-Volume Control:

1. Prerequisites: Installation verification of the following:

- a. Volume Control Input Device: [**Static-pressure transmitter**] [**Differential-pressure switch**] sensing supply-duct static pressure referenced to conditioned-space static pressure.
- b. Volume Control Output Device: [**Receiver controller**] [**DDC system analog output**] [**DDC system analog output to digital-to-pneumatic transducer**] to modulating damper actuator. Set inlet guide vanes to [**minimum**] [**closed**] position when fan is stopped.
- c. Volume Control Input Device: [**Static-pressure transmitter**] [**Differential-pressure switch**] sensing supply-duct static pressure referenced to conditioned-space static pressure.
- d. Volume Control Output Device: [**Receiver controller**] [**DDC system analog output**] to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
- e. High-Pressure Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
- f. High-Pressure Output Device: [**Receiver controller**] [**DDC system binary output**] to [**alarm panel**] [**motor starter**].
- g. Display the following at the operator's workstation:
 - 1) Supply-fan-discharge static-pressure indication.
 - 2) Supply-fan-discharge static-pressure set point.

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- 3) Supply-fan airflow rate.
 - 4) Supply-fan **[inlet vane position]** **[speed]**.
2. Scope: VAV supply fan units and associated controls.
3. Purpose:
 - a. Supply-air discharge static pressure control.
 - b. Response to excess supply-air discharge static pressure condition.
4. Conditions of the Test:
 - a. Minimum supply-air flow.
 - b. Midrange Supply-Air Flow: **[50 to 60]** **<Insert number(s)>** percent of maximum.
 - c. Maximum supply-air flow.
 - d. Excess supply-air discharge static pressure.
5. Acceptance Criteria:
 - a. At all supply-air flow rates, and during changes in supply-air flow, discharge air static pressure is at set point plus or minus **[2]** **<Insert number>** percent.
 - b. Fan stops, and an alarm is initiated at the operator's workstation when supply-air discharge static pressure is at the excess static pressure, plus or minus **[2]** **<Insert number>** percent.

B. Air-Handler Mixed-Air Control:

1. Prerequisites: Installation verification of the following:
 - a. Minimum Position Input Device: **[Time clock]** **[DDC system time schedule]**.
 - b. Output Device: **[Receiver controller]** **[DDC system analog output]** **[DDC system analog output to digital-to-pneumatic transducer]** to modulating damper actuator(s).
 - c. Heating Reset Input Device: **[Room thermostat]** **[DDC system software]**.
 - d. **[Supply]** **[Mixed]-Air** Temperature Input Device: **[Duct-mounted thermostat]** **[Electronic temperature sensor]**.
 - e. Cooling Reset Input Device: Outdoor- and return-air, duct-mounted **[thermostats]** **[electronic temperature sensors]**.
 - f. Display the following at the operator's workstation:
 - 1) Mixed-air-temperature indication.
 - 2) Mixed-air-temperature set point.
 - 3) Mixed-air damper position.
2. Scope: Air handler with mixed-air control and associated controls.
3. Purpose:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Occupied time control.
- b. Minimum damper position control.
- c. Heating reset control.
- d. [Supply] [Mixed]-air temperature control.
- e. Cooling reset control.
- f. Unoccupied time control.

4. Conditions of the Test:

- a. Occupied Time Control: Start in unoccupied schedule. Advance to occupied schedule time.
- b. Minimum Damper Position Control: Command system to mode in which minimum damper position is required.
- c. Heating Reset Control: Create a call for heating.
- d. [Supply] [Mixed]-Air Temperature Control: Override [supply] [mixed]-air temperature set point to a value [2.0 deg F] <Insert temperature> above current [supply] [mixed]-air temperature.
- e. Cooling Reset Control: Override outdoor-air [temperature to a value that exceeds return-air temperature] [enthalpy to a value that exceeds return-air enthalpy].
- f. Unoccupied Time Control: Advance to unoccupied schedule time.
- g. Control Data Trend Log: Set up a data trend log of the following input device values and output device commands. Record data at [hourly] <Insert alternative recording frequency> intervals. Submit trend data for [24-hour] <Insert time> periods in which natural conditions require heating reset control, [supply] [mixed]-air temperature control, and cooling reset control.
 - 1) Minimum position input device.
 - 2) Heating reset input device.
 - 3) [Supply] [Mixed]-air temperature input device.
 - 4) Cooling reset input device.

5. Acceptance Criteria:

- a. Occupied Time Control: Mixed-air control is active in occupied mode.
- b. Minimum Damper Position Control: Controller [opens minimum outdoor-air dampers] [positions outdoor-air dampers to minimum position].
- c. Heating Reset Control: Controller [closes minimum outdoor-air dampers] [sets outdoor-air dampers to minimum position].
- d. [Supply] [Mixed]-Air Temperature Control: Controller modulates outdoor-, return-, and relief-air dampers to maintain temporary [supply] [mixed]-air temperature set point, plus or minus [1.0 deg F] <Insert temperature>.
- e. Cooling Reset Control: Controller sets outdoor-air dampers to minimum position when outdoor-air [temperature exceeds return-air temperature] [enthalpy exceeds return-air enthalpy].

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- f. Unoccupied Time Control: Controller positions outdoor- and relief-air dampers closed and return-air dampers open.
- g. Control Data Trend Log: Data verify control according to sequence of control.

END OF SECTION

SECTION 23 09 00
BUILDING MANAGEMENT SYSTEM (BMS)
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 50)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.02 SUMMARY:

- A. The requirements of Division 1, the General Conditions, the Supplementary General Conditions, the Related Documents and the contract drawings are hereby made a part of this Section as fully as if repeated herein.
- B. All of the Sections in this Division shall be considered as forming a part of the specifications and shall be carefully examined before proposals for any work are submitted.

1.03 SCOPE OF WORK

- A. The BMS contractor shall design, furnish, install, and implement a complete building management system including all labor, necessary hardware, and operating and applications software necessary to perform the control sequence of operation as detailed in the contract documents.
- B. Labor shall include, but not be limited to:
 - 1. Hardware engineering to produce submittals and shop drawings as specified
 - 2. Software engineering for required software programming
 - 3. Software engineering for integration of systems listed in 1.6.3
 - 4. Software engineering for required graphic display screen development
 - 5. Project management to coordinate activities during BMS design, installation, and implementation
 - 6. Field engineer or project management during controls installation and startup
 - 7. Installation of control wiring, sensing tubing, and related control devices
 - 8. Field technicians to perform BMS start up procedures
 - 9. Field technicians to perform BMS installation verification and operational verification
 - 10. Field technicians to assist Testing and Balancing (TAB) contractor in adjusting controls and determining setpoints related to TAB work
 - 11. Field technicians to demonstrate BMS functional readiness to the Cx
 - 12. Training for the Cx

13. Field technicians to support stability testing
 14. Training for the end user
- C. BMS hardware and software engineering shall be performed by factory trained engineers with proficiency in the BMS products being implemented. The BMS contractor's engineers shall have previously performed in capacity that qualifies them to successfully execute the scope of this project. The MEP consultant reserves the right to exclude engineers whose previous experience is not deemed sufficient enough to meet needs of this project.
 - D. The BMS shall be installed either by trained mechanics/technicians directly employed by the BMS contractor or by subcontractors who are under direct supervision of the BMS contractor's project manager.
 - E. The BMS contractor's engineers, mechanics, technicians, project managers, and installation subcontractors shall have previously performed in capacity that qualifies them to successfully execute the scope of this project.
 - F. The BMS contractor shall submit the qualifications/resumes of engineers, project managers, field supervisors, and technicians that will design, install, and implement the BMS on this project within 30 days after contract award.
 - G. The BMS contractor shall provide materials as specified unless approved through procedures for product substitution specified in Division 1.
 - H. The BMS contractor shall provide electrical products listed and labeled by UL and that meet compliance with NEMA Standards.
 - I. The BMS contractor shall provide weather protection where required for control devices located outdoors.
 - J. The BMS contractor shall be responsible for additional instrumentation described in the points lists or the MEP consultant's control drawings, which may not be required by the respective control sequence.
 - K. The BMS contractor shall be responsible for complete installation of control devices (except as noted), wiring, and pneumatic terminations at controller and device locations to accomplish control sequences.
 - L. The BMS contractor shall provide and install power wiring for air terminal controllers and other field mounted devices that require 24 VAC. These devices shall be powered from 120 to 24 VAC transformer panels provided by the BMS contractor.
 - M. The BMS contractor shall provide install interlock wiring for boilers, chillers, and fuel oil system.
 - N. The mechanical contractor shall provide wells, taps, and other mechanical interfaces required for mounting of control equipment into piping systems. The mechanical contractor shall install in-line devices in piping and ductwork, such as valves, dampers, flow meters, and air flow stations, furnished by the BMS contractor. The BMS contractor shall be responsible for the installation of the remaining control devices, such as actuators, sensors, flow transmitters, remote mounted control transmitters, control panels, and control

transformers.

- O. Electrical work required as part of the BMS is responsibility of the BMS contractor. The BMS contractor is responsible to provide final power connections, including conduit, wire, and disconnect switches, to control devices from designated electrical distribution panels.
 - 1. The electrical contractor shall provide circuit breakers required to provide electrical power to BMS control panels as indicated on floor plan drawings. This scope must be closely coordinated prior to contractual agreement.
 - 2. 120 to 24 VAC transformers shall be provided by the BMS contractor. They shall be installed inside BMS control panels, and be powered from the designated electrical circuits.
 - 3. 120 to 24 VAC transformer panels for power to VAV boxes shall be provided by the BMS contractor. They shall be installed near the VAV boxes being served, and be powered from the designated electrical circuits.
- P. Any part/device or equipment installed as part of the BMS found to be malfunctioning or defective during the warranty period shall be replaced by the BMS contractor within 48 hours from the time the problem was reported.
- Q. The BMS contractor shall provide labor, material, equipment, related services, and supervision for implementation of the Embedded Power and Energy Management Software (PEMS) system and specified in section 2.2.2.6.
- R. Motor starting equipment provided by Division 21, 22, 23 for mechanical units shall meet the requirements of this section.

1.04 RELATED DOCUMENTS

- A. Refer to Section 230000 General Requirements, for applicable contract documents and work requirements.

1.05 DEFINITIONS

- A. The following list of definitions may contain terms not found elsewhere in the specification but are included here for completeness.
 - 1. BACnet: Building Automation and Control Network; the common name for the communication standard ASHRAE 135. The standard defines methods and protocol for cooperating building management devices to communicate over a variety of LAN technologies.
 - 2. BACnet Advanced Application Controller (B-AAC): A device that may be intended for a specific application but it supports some degree of programmability and has a richer set of features than a B-ASC.
 - 3. BACnet Building Controller (B-BC): A device that includes IP to Field Bus router, automatic time scheduling, trend logging, alarm handling, and supervisory logic control functionality.
 - 4. BACnet over Internet Protocol (BACnet/IP): An extension of BACnet, Annex J, defines this mechanism using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
 - 5. BACnet Internetwork: Two or more BACnet networks, possibly using different LAN technologies, connected with routers. In a BACnet internetwork, there exists

- only one message path between devices.
6. BACnet Network: One or more BACnet segments that have the same network address and are interconnected by bridges at the physical and data link layers.
 7. BACnet Segment: One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.
 8. BACnet Smart Actuator (B-SA) and BACnet Smart Sensor (B-SS): Each device used in new construction is required to have a PICS statement listing BIBBs supported.
 9. BACnet Interoperability Building Blocks (BIBBs): A collection of BACnet services used to describe supported tasks. BIBBs are often described in terms of "A" (client) and "B" (server) devices. The "A" device uses data provided by the "B" device, or requests an action from the "B" device.
 10. BI: BACnet International, formerly the following two organizations:
 - a. BACnet Manufacturers Association (BMA)
 - b. BACnet Interest Group - North America (BIG-NA)
 11. BI/BTL: BACnet International/BACnet Testing Laboratories, formerly BMA/BTL. The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.
 12. Binary (or Digital): A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level.
 13. Binding: The act of establishing communications between BACnet devices by associating the output of a device to the input of another.
 14. Building Control Network: The ASHRAE 135 control network installed under this specification, consisting of a backbone and one or more local control busses.
 15. Building Management System (BMS) Software: The 'front end' software which performs supervisory functions such as alarm handling, scheduling, logging, reporting, and trending, and provides a user interface for monitoring and configuring these functions.
 16. Configuration Parameter: Controller setting usually written to EEPROM.
 17. Device Object: Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet internetwork. This number is often referred to as the device instance.
 18. Device Profile: A collection of BIBBs determining minimum BACnet capabilities of a device, defined in ASHRAE Standard 135. Standard device profiles include BACnet Operator Workstations (B-OWS), BACnet Building Controllers (B-BC), and BACnet Advanced Application Controllers (B-AAC).
 19. Gateway: A device that translates from one protocol to another. Gateways are also called Communications Bridges or Protocol Translators.
 20. Media Access Control (MAC) Address: The physical node address that identifies a device on a Local Area Network.
 21. Master-Slave/Token-Passing (MS/TP): ISO/IEC 8802 (Part 3). One of the LAN options for BACnet. MS/TP uses twisted-pair wiring for relatively low speed and low cost communication (up to 4,000 ft at 76.8K bps).
 22. Native BACnet Device: A device that uses BACnet as its primary, if not only, method of communication with other BACnet devices without intermediary gateways. A system that uses native BACnet devices at all levels is a native BACnet system.
 23. Network: Communication technology for data communications. BACnet approved network types are BACnet/IP and MS/TP.

- 24. Network Number: A site-specific number assigned to each network segment to identify for routing. This network number must be unique throughout the BACnet internetwork.
- 25. Node: A device that communicates using the BACnet MS/TP protocol and is connected to a BACnet MS/TP network.
- 26. Node Address: The logical address of a node on the network.
- 27. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.
- 28. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.
- 29. Object Properties: Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.
- 30. Protocol Implementation Conformance Statement (PICS): PICS describes the BACnet capabilities of a device.
- 31. Repeater: A device that connects two control network segments and retransmits all information received on one side onto the other.
- 32. Router: A device that connects two channels and controls traffic between the channels by retransmitting signals received from one subnet onto the other based on the signal destination. Routers are used to subdivide a control network and to control bandwidth usage.
- 33. Segment: A 'single' section of a control network that contains no repeaters or routers. The device quantity limitation is dependent on the topology/media and device type.

1.06 SUBCONTRACTOR QUALIFICATIONS

- A. All bidders must be building management system contractors in the business of installing direct digital control building management systems for a minimum of ten years.
- B. All bidders must have a proven record of experience in the supply and installation of equivalent systems. Bidders may be asked to document at least three projects of equal or greater size and complexity.
- C. Bidders that have not been pre-qualified may also be asked to submit a technical proposal to the end user, MEP consultant, and/or CM that includes BMS technical information, detailed information about past projects, hardware and software submittals from past projects, line by line specification compliance, references, personnel resumes, financial information, and current workload.
- D. The Building Management System (BMS) contractor shall have a full service facility within 75 miles of the project that is staffed with engineers trained and certified by the manufacturer in the configuration, programming and service of the BMS. The BMS contractor's technicians shall be fully capable of providing instructions and routine emergency maintenance service on all system components.
- E. All bidders must be authorized distributors or branch offices of the manufacturers specified.

- F. The following bidders have been pre-qualified:
1. Schneider Electric

1.07 BUILDING MANAGEMENT SYSTEM DESCRIPTION

- A. The Building Management System (BMS) shall be a single complete non-proprietary Direct Digital Control (DDC) system for control and monitoring of the heating, ventilating and air conditioning (HVAC), utilities, and other building systems as specified and shown. Refer to the control drawings and sequence of operation for detailed applications.
- B. The BMS shall comprise the following components:
1. Engineering Workstations
 2. Enterprise Server / Report Server
 3. Operator Interface Software
 4. Graphical Web-Based User Interface
 5. Network Controllers / Automation Servers
 6. Distributed Controllers and Enclosures
 7. Unitary Controllers
 8. Handheld Devices
 9. Management Level and Field Level Networks
 10. Field Instrumentation
 11. Automatic Dampers and Valves
 12. Actuators for Automatic Dampers and Valves
 13. Air Flow Stations
 14. Energy Meters
 15. Power Meters
 16. Variable Frequency Drives
 17. Software Interfaces to Systems Provided by Others
 18. All power supplies and conditioners, interlocking and control relays, equipment enclosures, conduit, junction and mounting boxes, cabling, access doors, sleeves, fire stopping, and other components, materials and services required for a completed and fully operational turnkey BMS installation meeting these specifications.
- C. The BMS's web-based graphical user interface shall allow access to the BMS through a standard browser.
- D. The BMS shall be capable of functioning as a data historian for long term data archiving.

1.08 BUILDING MANAGEMENT SYSTEM REQUIREMENTS

- A. Building Management Systems installed under this specification shall have the following:
1. The BMS shall be based on an open implementation of BACnet using ASHRAE 135 exclusively as the communications protocol for communication between BMS hardware devices.
 2. The BMS hardware and software shall perform the control sequences as specified and shown in the MEP consultant's control drawings and sequence of operation.
 3. The engineering workstations must be running the standard workstation software developed and tested by the manufacturer of the BMS controllers. No third party front-end workstation software shall be acceptable. Engineering workstations must conform to the B-OWS BACnet device profile.

4. Web-based users shall have access to all system points and graphic display screens, shall be able to receive and acknowledge alarms, and shall be able to control setpoints and other parameters. All engineering work, such as trends, reports, that are accomplished from the engineering workstation shall be available for viewing through the web browser interface. The web-based interface must conform to the B-OWS BACnet device profile. There shall be no need for additional computer based hardware to support the web-user interface.
5. All BMS controllers shall be connected to an ASHRAE 135 BACnet/IP or MS/TP control network.
6. Control sequence logic for a particular system shall reside in that system's dedicated BMS controller. The hardware in conjunction with the software residing on the controller shall, where possible, execute the sequence of operation without relying on the building network.
7. The BMS shall be designed and installed such that the end user is able to perform repair, replacement, upgrades, and expansions of the system without further dependence on the original BMS contractor. BMS implementation documentation, configuration information, configuration tools, application programs (with comments explaining program logic), and other software used by the BMS shall be licensed to and remain property of the end user
8. The BMS will monitor Power and Utilities per M&V Plan to be reported accordingly.
9. The BMS shall have capability for an embedded web-enabled PEMS (power and energy management system) monitoring system intended to monitor an entire electrical distribution infrastructure, from incoming utility feeds down to low voltage distribution points. It shall be designed to monitor and manage energy consumption throughout an enterprise, whether within a single facility or across a network of facilities, to improve energy availability and reliability, and to measure and manage energy efficiency. It shall be a standard product offering with no custom programming required. It shall provide a seamless user experience ("Single pane of glass") for managing the mechanical systems (HVAC and lighting) and monitoring the power distribution system (transformers, breakers, relays, switches, capacitors, UPS, invertors, etc.)

1.09 INTEGRATION REQUIREMENTS

- A. The BMS contractor shall be responsible for integration of the following independent systems into the BMS, as indicated on control drawings and as described in the sequence of operation and the integration specification. The BMS contractor shall assume that all necessary hardware for integration (i.e., BACnet cards) is provide by the equipment manufacturer.
 1. Boilers:
 - a. Boiler provider shall provide a termination point for a single point communication connection to the BMS utilizing BACnet I/P or BACnet MS/TP protocol.
 - b. The BMS contractor shall provide cabling and conduit, if necessary, to make an interface connection from the BMS to the boiler point of connection.
 - c. The BMS contractor and boiler provider are responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems.
 - d. The BMS contractor must refer to the boiler specification, integration specification, and

sequence of operation for programming and monitoring requirements.

- e. The following I/O and variables shall be monitored by the BMS when available from the local boiler control panel:
 - 1) Boiler Enable/Disable Command
 - 2) Burner Status
 - 3) Burner VFD
 - 4) Hot Water Supply to Building
 - 5) Hot Water Supply from Boilers
 - 6) Hot Water Return to Boilers
 - 7) Hot Water Return from Building
 - 8) Boiler Alarm
 - 9) Stack Temperature
 - 10) Boiler Isolation Valve
 - 11) Boiler Isolation Valve Status
- f. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the boiler vendor for this integration. This integration shall be done via BACnet IP or BACnet MS/TP.

2. Chillers:

- a. Chiller provider shall provide a termination point for a single point communication connection to the BMS utilizing BACnet I/P or BACnet MS/TP protocol.
- b. The BMS contractor shall provide cabling and conduit, if necessary, to make an interface connection from the BMS to the chiller point of connection.
- c. The BMS contractor and chiller provider are responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems.
- d. The BMS contractor must refer to the chiller specification, integration specification, and sequence of operation for programming and monitoring requirements.
- e. The following I/O and variables shall be monitored by the BMS when available from the local chiller control panel:
 - 1) Chiller Start/Stop Command
 - 2) Local Schedule
 - 3) Occupancy
 - 4) Remote Start Control
 - 5) Run Status Code
 - 6) Alarm Value
 - 7) System Alarm Code
 - 8) Entering Condenser Temperature
 - 9) Leaving Condenser Temperature
 - 10) Condenser Water Flow
 - 11) Condenser Water Pump
 - 12) Condenser refrigerant Temperature
 - 13) Condenser Pressure
 - 14) Line Current
 - 15) Line Voltage
 - 16) Line Frequency
 - 17) Line Power Factor

- 18) Demand Limit
- 19) System Load
- 20) System Demand Limit
- 21) Guide Vane Command
- 22) Guide Vane Position
- 23) VFD Speed Command
- 24) VFD Speed Feedback
- 25) Evaporator Saturation Temperature
- 26) Evaporator Refrigerant Temperature
- 27) Oil Sump Temperature
- 28) Communications Status
- 29) Communications Alarm
- 30) Equipment Alarm
- 31) Compressor Discharge Temperature
- 32) Motor Winding Temperature
- 33) Thrust Bearing Temperature
- 34) Chiller Runtime
- 35) Leaving CHW Temperature
- 36) CHW Temperature Setpoint
- 37) Control Temperature Setpoint
- 38) Chilled Water Temperature
- 39) Entering Chilled Water Temperature
- 40) Chilled Water Deadband
- 41) Chilled Water Delta T

- f. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the Chiller vendor for this integration. This integration shall be done via BACnet IP or BACnet MS/TP.

3. Variable Frequency Drives (VFD):

- a. VFD provider shall provide a termination point for a single point communication connection to the BMS utilizing BACnet I/P or BACnet MS/TP protocol.
- b. BMS contractor shall provide cabling and conduit to make an interface connection from the BMS to the VFD.
- c. The BMS contractor and VFD provider are responsible for translation of network protocols, testing of communications between systems, and joint commissioning of systems.
- d. The BMS contractor must refer to the VFD specification, integration specification, and sequence of operation for programming and monitoring requirements.
- e. The following I/O and variables shall be monitored by the BMS when available from the VFD:

- 1) Run Status
- 2) Forward / Reverse Status
- 3) Fault Status
- 4) Hand / Auto Status
- 5) Drive Ready Status
- 6) At Setpoint Status
- 7) Run/Stop Command
- 8) Resets Faults
- 9) Output Speed min-1

- 10) Output Frequency Hz
 - 11) DC Bus Voltage V
 - 12) Motor Voltage V
 - 13) Motor Current A
 - 14) Motor Torque %
 - 15) Motor Power %
 - 16) Drive Thermal State %
 - 17) Energy Counter kWh
 - 18) Run Time
 - 19) Last Error Code
- f. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the VFD vendor for this integration. This integration shall be done via BACnet IP or BACnet MS/TP.
4. Lighting Control System (LCS):
- a. LCS provider shall provide all system information to the BMS via BACnet/IP communication protocol as indicated in design documents.
 - b. The BMS contractor and LCS provider are responsible for translation of network protocols, testing of communications between systems, and joint commissioning of systems.
 - c. The BMS contractor must refer to LCS specification, integration specification, and sequence of operation for programming and monitoring requirements.
 - d. The following I/O and variables shall be monitored and controlled if available by the BMS when available:
 - 1) Lights On/Off
 - 2) Lights On/Off State
 - 3) Lights Dim Level
 - 4) Room Light Level
 - 5) Occupancy Status
 - 6) Wall Switch Position
 - 7) Outside Light Level
 - e. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the lighting control system vendor for this integration. This integration shall be done via BACnet IP.
5. Computer Room Air Conditioning Units (CRACs):
- a. CRAC provider shall provide a termination point for a single point communication connection to the BMS utilizing BACnet I/P or BACnet MS/TP protocol.
 - b. The BMS contractor shall provide cabling and conduit, if necessary, to make an interface connection from the BMS to the CRAC point of connection.
 - c. The BMS contractor and CRAC provider are responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems.
 - d. The BMS contractor must refer to the CRAC specification, integration specification, and sequence of operation for programming and monitoring requirements.
 - e. The following I/O and variables shall be monitored by the BMS when available from the CRACs:
 - 1) Space Temperature
 - 2) Space Humidity

- 3) Unit Status
 - 4) Unit Runtime
 - 5) General Alarm
- f. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the plumbing contractor for this integration. This integration shall be done via BACnet IP or BACnet MS/TP.
- 6. Emergency Generator:
 - a. Emergency generator provider shall provide a termination point for a single point communication connection to the BMS utilizing BACnet IP, ModBus TCP/IP, or ModBus RTU protocol.
 - b. The BMS contractor shall provide cabling and conduit, if necessary, to make an interface connection from the BMS to the emergency generator point of connection.
 - c. The BMS contractor and emergency generator provider are responsible for translation of network protocols, testing of communications between systems, and joint commissioning of systems.
 - d. The BMS contractor must refer to the emergency generator specification, integration specification, and sequence of operation for programming and monitoring requirements.
- 7. Energy Meters:
 - a. Meter provider shall provide a termination point for a single point communication connection to the BMS utilizing BACnet I/P, BACnet MS/TP, Modbus TCP/IP, or Modbus RTU protocol.
 - b. The BMS contractor shall provide cabling and conduit, if necessary, to make an interface connection from the BMS to the meter point of connection.
 - c. The BMS contractor and meter provider are responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems.
 - d. The BMS contractor must refer to the respective meter specification, integration specification, and sequence of operation for programming and monitoring requirements.
- 8. Uninterruptible Power Supply (UPS):
 - a. UPS provider shall provide a termination point for a single point communication connection to the BMS utilizing BACnet I/P, Modbus TCP/IP, or Modbus RTU protocol.
 - b. The BMS contractor shall provide cabling and conduit, if necessary, to make an interface connection from the BMS to the UPS point of connection.
 - c. The BMS contractor and UPS provider are responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems.
 - d. The BMS contractor must refer to the UPS specification, integration specification, and sequence of operation for programming and monitoring requirements.
 - e. The following I/O and variables shall be monitored by the BMS when available from the VFDs:

- 1) Communication Alarm
- 2) Battery Circuit Open
- 3) Battery Discharging
- 4) Low Battery Shutdown
- 5) Mains 1 Input Switch Open
- 6) Mains 1 Voltage Alarm
- 7) Emergency Off Switch
- 8) Operating On Battery
- 9) Forced Inverter Shutdown
- 10) Inverter Output Switch Open
- 11) Inverter Stack Overload
- 12) Inverter Sync with Mains 2
- 13) Inverter Thermal Override
- 14) Maintenance Bypass
- 15) Rectifier Charge Input Volt Alarm
- 16) System Not Normal
- 17) Transfer Lockout
- 18) Unsafe Operation
- 19) KVA
- 20) Load Voltage A-B
- 21) Load Voltage B-C
- 22) Load Voltage C-A
- 23) KW
- 24) Mains 1 Voltage A-B
- 25) Mains 1 Voltage B-C
- 26) Mains 1 Voltage C-A

f. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the UPS manufacturer for this integration. This integration shall be done via BACnet I/P, Modbus TCP/IP.

9. Fire Alarm System (FAS):

- a. FAS provider shall provide all required system information to the BMS via BACnet/IP communication protocol as indicated in design documents.
- b. The BMS contractor and FAS provider are responsible for translation of network protocols, testing of communications between systems, and joint commissioning of systems.
- c. The BMS contractor must refer to the FAS specification, integration specification, and sequence of operation for monitoring requirements.

1.10 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Air Flow Stations
- B. Control Dampers
- C. Control Valves
- D. Flow Meters (including BTU Meters)
- E. Terminal Unit Controls

F. Temperature Sensor Wells

G. Electrical Meters

H. See coordination matrix in section 1.6.5 for further detail.

1.11 COORDINATION MATRIX FOR MECHANICAL/ELECTRICAL/PLUMBING TRADES

<u>Description</u>	<u>Furnish</u>	<u>Install</u>	<u>Control</u>	<u>Control Wiring</u>	<u>Power Wiring</u>
Air Compressor	Mechanical	Mechanical	Mechanical	BMS	Electrical
Air Flow Stations & Transmitters	BMS	Mechanical	BMS	BMS	BMS
BMS low voltage and communication wiring	BMS	BMS	N/A	BMS	N/A
BMS conduits and raceway	BMS	BMS	N/A	BMS	BMS
Combination Fire/Smoke Damper & Actuators	Mechanical	Mechanical	Fire Alarm	Electrical	Electrical
Concrete Pads / Seismic Restraints	Mechanical	Mechanical	N/A	N/A	N/A
Control Dampers	BMS	Mechanical	N/A	N/A	N/A
Control Damper Actuators	BMS	BMS	BMS	BMS	BMS
Control Valves	BMS	Mechanical	BMS	BMS	BMS
Current Relays	BMS	BMS	BMS	BMS	BMS
Current Sensors	BMS	BMS	BMS	BMS	BMS
Duct Smoke Detectors	Fire Alarm	Mechanical	Fire Alarm	Electrical	Electrical
Electrical Meters	BMS	Electrical	N/A	BMS	BMS
Fire Shutdown Relay	Fire Alarm	Fire Alarm	BMS	BMS	Electrical
Fireman's Override Panel	Fire Alarm	Fire Alarm	Fire Alarm	Electrical	Electrical
Flow Meters	BMS	Mechanical	BMS	BMS	BMS
Interlock/Trim Wiring for Chiller/Boiler/Fuel Oil	N/A	BMS	N/A	N/A	N/A

<u>Description</u>	<u>Furnish</u>	<u>Install</u>	<u>Control</u>	<u>Control Wiring</u>	<u>Power Wiring</u>
Refrigerant Detection System	N/A	BMS	BMS	BMS	BMS
Smoke Dampers & Actuators	Mechanical	Mechanical	BMS	BMS	BMS
Smoke Purge Sequences	N/A	N/A	Fire Alarm	Fire Alarm	Fire Alarm
Static Pressure Reference	BMS	BMS	N/A	N/A	N/A
Unit Heater Controls	Mechanical	Mechanical	Local	BMS	BMS
VAV Boxes	Mechanical	Mechanical	BMS	BMS	BMS
VAV Box Controller Mounting	N/A	Mechanical	Mechanical	Mechanical	Mechanical
Variable Frequency Drives	BMS	Electrical	BMS	BMS	Electrical

1.12 SYMBOLS AND ENGINEERING UNIT ABBREVIATIONS

- A. Symbols and engineering unit abbreviations used in BMS graphic display screens, submittals, and reports shall be as shown in the MEP consultant's drawings.

1.13 SYSTEM UNITS AND ACCURACY

- A. BMS shop drawings, graphic display screens, and reports shall be shown with English (inch-pound) units.
- B. BMS shop drawings, graphic display screens, and reports shall have precision and resolution equal to or exceeding sensor accuracy as specified.
- C. Calculations shall have accuracy equal to or exceeding sensor accuracy as specified.

1.14 CONTRACT DRAWING LIMITS

- A. The MEP consultant will not indicate all offsets, fittings, and accessories that may be required on the drawings.
- B. The BMS contractor shall carefully investigate the architectural, mechanical, electrical, and plumbing conditions that could affect the work to be performed.

1.15 DOCUMENTATION

- A. The purpose of the documentation is to provide relevant information to those responsible for designing, installing, implementing, and maintaining the BMS.
- B. The MEP consultant shall thoroughly review the documentation and identify as many potential areas of non-conformance as possible.

1.16 COORDINATION DRAWINGS

- A. The BMS contractor shall participate in the development of coordinated drawings with the mechanical and electrical contractors. The mechanical contractor shall indicate all mechanical, plumbing, and fire protection work on the drawings. The electrical contractor shall then add the electrical, fire alarm, and communication system work to the drawings. The BMS contractor shall indicate the required BMS work on the drawings for the following:
 - 1. Cable tray installed by the BMS contractor
 - 2. Conduits over 2" installed by the BMS contractor
 - 3. Sleeves required for BMS work
 - 4. Devices above the ceiling or below a raised floor requiring access
 - 5. Control panels
- B. The BMS contractor shall assist and cooperate with the other trades to ensure a complete and coordinated set of drawings has been generated.

1.17 BUILDING INFORMATION MODELING (BIM)

- A. The BMS contractor shall participate in the development of a Building Information Model with the architects, mechanical and electrical contractors. The mechanical contractor shall indicate all mechanical, plumbing, and fire protection work on the model. The electrical contractor shall then add the electrical, fire alarm, and communication system work to the model. The BMS contractor shall indicate the required BMS work on the model for the following:
 - 1. Cable tray installed by the BMS contractor
 - 2. Conduits over 2" installed by the BMS contractor
 - 3. Sleeves required for BMS work
 - 4. Devices above the ceiling or below a raised floor requiring access
 - 5. Control panels
- B. The BMS contractor shall assist and cooperate with the other trades to ensure a complete model has been generated.

1.18 SHOP DRAWINGS

- A. The BMS contractor shall prepare all shop drawings in Visio Professional software. Drawings shall be 11"x17". In addition to the hard copy, the BMS contractor shall furnish an electronic copy of the identical information. Information shall be bound or in a three ring binder with an appropriate index and tabs. If color has been used to differentiate information, the printed copies shall be in color.
- B. The BMS design package shall include the following:
 - 1. Valve Schedule: The valve schedule shall contain each valve's unique tag name, size, flow coefficient Kv (Cv), pressure drop at specified flow rate, spring range, actuator size and close-off pressure to torque data. The valve schedule shall contain actuator selection data supported by calculations of the force required to move and seal the valve, access and clearance requirements.
 - 2. Damper Schedule: The damper schedule shall contain each damper's unique tag name, type (opposed or parallel blade), nominal and actual sizes, orientation of axis and frame, direction of blade rotation, actuator size and spring ranges,

operation rate, location of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. The damper schedule shall include the AMCA 500-D maximum leakage rate at the operating static-pressure differential.

3. Flow Meter Schedule: The flow meter schedule shall contain the unique tag name, manufacturer, model number, part number, descriptive name, and sizing information for each flow meter
4. Air Flow Station Schedule: The air flow station schedule shall contain the unique tag name, manufacturer, model number, part number, descriptive name, and duct size for each air flow station.
5. Drawing Index and Drawing Legend: The drawing index shall list all BMS contractor drawings, including the drawing number, sheet number, drawing title. The drawing legend shall show and describe all symbols, abbreviations, and acronyms used on the BMS drawings.
6. Riser Diagram of Building Control Network: The riser diagram of the building control network shall show all network cabling, BMS hardware, and network hardware including:
 - a. All BMS hardware with room number, unique identifiers, and common descriptive names
 - b. All computer and network hardware with room number, unique identifiers, and common descriptive names
 - c. All BMS network cabling and power wiring (can be shown as a depiction on each piece of BMS hardware and does not have to depict the actual routing of the network)
 - d. All other devices connected to the BMS IP or MS/TP network
 - e. IP address(es) as applicable for each piece of network hardware and computer hardware
7. Control System Schematic Drawings: The control system schematic drawings shall be in the same form as the MEP consultant's control system schematic drawings with the BMS contractor providing updated information and detail as required. A control system schematic shall be submitted for each system controlled or monitored by the BMS.
8. Controller, Motor Starter and Relay Wiring Drawing: The controller wiring drawings shall be functional wiring drawings which show the interconnection of conductors and cables to each controller and to the identified terminals of input and output devices, starters and package equipment. The wiring drawings shall show all necessary jumpers, ground connections, and the labels of all conductors. Sources of power required for control systems and for packaged equipment control systems shall be identified back to the panel board circuit breaker number, controller enclosures, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not integral to a controller, starter, or packaged equipment shall be shown. Wiring drawings shall be submitted for each system controlled or monitored by the BMS. Typical wiring drawings shall be acceptable as long as the systems they represent are clearly marked.
9. Control Panel Layout Drawing: Control panel layout drawings shall be to scale with all devices shown in their proposed positions. All control devices shall be identified by name. All terminal strips, control transformers, IP connection points, devices and wire channels shall be shown.
10. Points List: A Points List shall be submitted for each system controlled or monitored by the BMS. The Points List shall include, name, description, range, engineering units, and alarm(s).

11. Sequence of Operation: The HVAC control system sequence of operation shall be in the same format as the MEP consultant's sequence of operation and shall refer to the devices by their unique identifiers/tags. No operational deviations from specified sequences shall be permitted without prior written approval of the MEP consultant. Sequence of operation should be submitted for each system controlled by the BMS.
- C. Submit five (5) copies of submittal data and shop drawings to the MEP consultant for review prior to ordering or fabrication of the equipment.
- D. A piecemeal submittal process shall be acceptable prior to complete comprehensive final submission as follows:
 1. Equipment submittals (if applicable)
 2. In-line device schedules (i.e., valves, dampers, flow stations, flow meters requiring long times)
 3. First shop drawing submission of each typical system
 4. Control panel layout drawings
 5. Sample software graphic display screens
- E. The MEP consultant shall make corrections, if required, and return to the BMS contractor. The BMS contractor shall then resubmit with the corrected or additional data. This procedure shall be repeated until all corrections are made to the satisfaction of the MEP consultant and the shop drawings are fully approved.
- F. The following is a list of post construction submittals that shall be updated to reflect any changes during construction and re-submitted as "As-Built".
 1. System architecture/riser drawing
 2. System control schematic drawing for each controlled system
 3. Points list for each controlled system
 4. Wiring drawing for individual components
 5. Control panel layout drawings
 6. Sequence of operation

1.19 COMMISSIONING DOCUMENTATION

- A. The BMS contractor shall coordinate with the commissioning process specified in specification section 01 91 13 and specification section 25 08 00.

1.20 DELIVERY AND STORAGE

- A. The BMS contractor shall ensure that all products are stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants, and within the storage condition tolerances published by the respective equipment or device manufacturer.

1.21 OPERATION AND MAINTENANCE MANUALS

- A. The intent of the operation and maintenance documentation is to provide the end user with complete information on the BMS as it was installed. The record documentation shall be in such detail that a person familiar with a BMS installation of this nature shall be able to

perform any operating, maintenance, or engineering functions with respect to this BMS without having to contact the BMS contractor or obtain any additional documentation.

B. The BMS contractor shall submit (5) operation and maintenance manuals that include the following three sections:

1. BMS Hardware As-Built Information

- a. Riser Diagram of Building Control Network
- b. As-built control schematic drawing for each controlled system
- c. As-built wiring drawings for all components
- d. As-built drawings for each control panel layout
- e. Installation details for each I/O device
- f. Product data sheet for each component
- g. Installation data sheet for each component
- h. As-built sequence of operation for each system
- i. Procedures for HVAC system start-up, operation, and shut-down
- j. Printouts of configuration settings for all devices
- k. Routine maintenance/calibration checklist: The routine maintenance checklist shall be arranged in a spreadsheet with the device tag, type of device, maintenance frequency, calibration frequency, and a notes field.
- l. Start-Up Testing Report
- m. List of hardwired points transmitted to the AMBC system and the APEO system

2. BMS Software As-Built Information

- a. Copy of all software installed on the servers and workstations
- b. All licensing information for all software installed on the servers and workstations
- c. All software revisions shall be as installed at the time of the system acceptance
- d. Copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
- e. Copy of all application files that were created during the execution of the project
- f. Copy of all graphic display screens created during the execution of the project
- g. List of virtual points configured from each software interface
- h. List of virtual points transmitted to the AMBC system and to the APEO system

3. BMS Operational Information

- a. Product manuals for the key software tasks:
 - 1) Operating the system
 - 2) Administrating the system
 - 3) Application programming
 - 4) Setting up the report server
 - 5) Report creation
 - 6) Graphics creation
- b. List of recommended maintenance tasks associated with the system servers, operator workstations, data servers:
 - 1) Define the task with recommended frequency.

- 2) Reference the product manual that includes instructions on executing the task.
- c. Contact information of the BMS contractor and service representatives for equipment and control systems
- d. Licenses, guarantees, and warranty documents for equipment and systems

1.22 WARRANTY PERIOD (PREVENTATIVE MAINTENANCE AND SERVICE)

A. General

1. The BMS contractor shall provide labor, materials, and equipment as necessary to maintain the entire BMS in an operational state as specified for a period of one year after successful completion of the CxC commissioning activities and acceptance by the end user.

B. Description of Work

1. During the One year warranty period, the BMS contractor shall ensure the manufacturer's required sensor and actuator calibration is still current, and all software and firmware upgrades are current.

C. Personnel

1. Services shall be performed by factory trained technicians with a minimum of one year experience servicing similar system installations.

D. Work Coordination

1. When possible all work shall be performed during regular working hours, Monday through Friday, excluding holidays.
2. The BMS contractor shall schedule and arrange work to cause the least interference to end user operations. If interference is essentially unavoidable, the BMS contractor shall carefully coordinate with the end user to minimize the impact of the inconvenience, equipment downtime, interrupted service, and personnel discomfort.
3. When the BMS contractor completes warranty work on a system or piece of equipment, that system or piece of equipment should function as originally intended and designed. Replacement parts shall conform to the same specifications as the original equipment.
4. The BMS contractor shall keep dated records and logs of each task performed during the warranty period. A continuous log shall be maintained for all devices. The log shall contain calibration values and digital setpoints. Logs shall be available for inspection onsite, with the purpose of demonstrating that planned adjustments and repairs have been accomplished for the BMS.
5. The BMS contractor shall be responsible for coordinating access to facilities and arranging that they be opened and closed during and after the completion of the work. For BMS contractor access to a controlled facility or area, the BMS contractor shall contact the end user for assistance.

E. Warranty Calls

1. The BMS contractor shall coordinate with end user and CM to develop warranty request protocols.
2. The end user will initiate warranty calls when the system is not functioning properly. The BMS contractor shall have qualified personnel available to service to the system. A telephone number where the BMS contractor's service dispatcher

- can be reached at all times shall be provided. The BMS contractor's service personnel shall be at the site within 24 hours after receiving a request for service.
3. In the event that the BMS contractor warranty call work causes damage to additional equipment, the BMS contractor shall be liable for labor and material to restore that equipment to proper operation as well.

F. System Modifications

1. BMS contractor recommendations for system modifications shall be submitted in writing. No system modifications, including modification of operating parameters and control settings, shall be made without prior approval of the end user. Any modifications made to the system shall be incorporated into the operation and maintenance manuals, and other impacted documentation.
2. The end user may replace, renovate, or install new equipment at their expense and by means not associated with this contract. Replaced, improved, updated, modernized, or renovated systems by the end user can only be added to the BMS contractor's service contract as a modification.

G. Power Line Filtering

1. The BMS contractor shall provide internal or external transient voltage and surge suppression for workstations and controllers. Equipment protection shall meet the requirements of IEEE C62.41.1 and IEEE C62.41.2. Fuses shall not be used for surge protection. Surge protection shall have:
 - a. Dielectric strength of 1000 V minimum
 - b. Response time of 10 nanoseconds or less
 - c. Transverse mode noise attenuation of 65 dB or greater
 - d. Common mode noise attenuation of 150 dB or greater at 40–100 Hz

1.23 BMS CONTROL NETWORK

A. General

1. The BMS control network shall consist of a building-level Ethernet network and one or more secondary floor-level BACnet MS/TP networks as specified.

B. Ethernet Network

1. The BMS contractor shall provide an Ethernet network.

PART 2 - PRODUCTS

2.01 REQUIREMENTS

A. General

1. Products of the same type and purpose shall be identical, including equipment, assemblies, parts and components.
2. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of these and similar products. The standard products shall have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two year use shall include applications of equipment and materials under similar circumstances and of similar size. BMS hardware not meeting the two-year field service requirement shall be acceptable provided it has been successfully used by the BMS contractor in a minimum of two previous

projects.

3. Where applicable, each major piece of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place.
4. The products used shall be supported by a service organization.
5. Manufacturer's data sheets documenting compliance with product specifications shall be submitted for each product installed under this specification.

B. Environmental Requirements

1. All products shall be rated for continuous operation under the following conditions:
 - a. Pressure: Pressure conditions normally encountered in the installed location
 - b. Vibration: Vibration conditions normally encountered in the installed location
 - c. Temperature:
 - 1) Products installed indoors: Ambient temperatures in the range of 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.
 - 2) Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of -10 to plus 151 degrees F and temperature conditions outside this range normally encountered at the installed location.
 - d. Humidity: 10 percent to 95 percent relative humidity, non-condensing and humidity conditions outside this range normally encountered at the installed location.

2.02 DIRECT DIGITAL CONTROL (DDC) SYSTEM HARDWARE AND SOFTWARE

A. General Requirements / System Architecture

1. The Building Management System (BMS) shall consist of Network Server/Controllers (NSCs), a family of Standalone Digital Control Units (SDCUs), Administration and Programming Workstations (APWs), and Web-based Operator Workstations (WOWs). The BMS shall provide control, alarm detection, scheduling, reporting and information management for the entire facility, and Wide Area Network (WAN) if applicable.
2. An enterprise level BMS shall consist of an Enterprise Server, which enables multiple NSCs (including all graphics, alarms, schedules, trends, programming, and configuration) to be accessible from a single Workstation simultaneously for operations and engineering tasks.
3. The enterprise level BMS shall be able to host up to 250 servers, or NSCs beneath it.
4. For enterprise reporting capability and robust reporting capability outside of the trend chart and listing ability of the Workstation, a Reports Server shall be installed on a Microsoft Windows based computer. The Reports Server can be installed on the same computer as the Enterprise Server.
5. The system shall be designed with a top-level 10/100bT Ethernet network, using the BACnet/IP, LonWorks IP, and/or Modbus TCP protocol.
6. Modbus RTU/ASCII (and J-bus), Modbus TCP, BACnet MS/TP, BACnet IP, LonTalk FTT-10A, and WebServices shall be native to the NSCs. There shall not be a need to provide multiple NSCs to support all the network protocols, nor there a need to supply additional software to allow all three protocols to be natively

supported. A sub-network of SDCUs using the BACnet MS/TP, LonTalk FTT-10A, and/or Modbus RTU protocol shall connect the local, stand-alone controllers with Ethernet-level Network Server Controllers/IP Routers.

7. TCP/IP Level
8. The TCP/IP layer connects all of the buildings on a single Wide Area Network (WAN) isolated behind the campus firewall. Fixed IP addresses for connections to the campus WAN shall be used for each device that connects to the WAN.
9. Fieldbus Level with Standalone Digital Control Units (SDCUs)
10. The fieldbus layer shall support all of the following types of SDCUs:
 - a. BACnet SDCU requirements: The system shall consist of one or more BACnet MS/TP field buses managed by the Network Server Controller. Minimum speed shall be 76.8kbps. The field bus layer consists of an RS485, token passing bus that supports up to 50 Standalone Digital Control Units (SDCUs) for operation of HVAC and lighting equipment. These devices shall conform to BACnet standard 135-2007
 - b. LonWorks SDCU requirements: The system shall consist of one or more LonWorks FTT-10A field buses managed by the Network Server Controller. Minimum speed shall be 76.8kbps. The field bus layer shall consist of up to 64 Lonworks SDCUs using peer-to-peer, event-driven communication for operation of HVAC and lighting equipment.
 - c. Modbus SDCU requirements: The system shall consist of one or more Modbus RTU (RS-485 or RS-232) field buses managed by the Network Server Controller. The field bus layer shall consist of up to 62 SDCUs for operation of HVAC, power metering, and lighting equipment. If utilizing Modbus TCP, the field bus layer shall consist of up to 100 SDCUs for operation of HVAC, power metering, and lighting equipment.
 - d. NETWORK 8000 SDCU requirements: The system shall consist of one or more ASD or LCM field buses managed by the Network Server Controller. The field bus layer shall consist of up to 128 ASD SDCUs or 31 LCM SDCUs for operation of HVAC, power metering, and lighting equipment.
 - e. I/NET SDCU requirements: The system shall consist of one or more controller LANs and subLANs managed by the Network Server Controller. The network shall consist of up to 100,000 I/NET points capable through numerous links and devices for operation of HVAC, power metering, and lighting equipment.
11. BMS LAN Segmentation
 - a. The BMS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN). Workstations can manage a single LAN (or building), and/or the entire system with all portions of that LAN maintaining its own, current database.
12. Standard Network Support
 - a. All NSCs, Workstation(s) and Servers shall be capable of residing directly on the owner's Ethernet TCP/IP LAN/WAN with no required gateways. Furthermore, the NSCs, Workstation(s), and Server(s) shall be capable of using standard, commercially available, off-the-shelf Ethernet infrastructure components such as routers, switches and hubs. With this design the owner may utilize the investment of an existing or new enterprise network or structured cabling system. This also allows the option of the maintenance of the LAN/WAN to be performed by the

owner's Information Systems Department as all devices utilize standard TCP/IP components.

13. System Expansion
 - a. The BMS system shall be scalable and expandable at all levels of the system using the same software interface, and the same TCP/IP level and fieldbus level controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.
 - b. Web-based operation shall be supported directly by the NSCs and require no additional software, other than a Java supported network browser.
 - c. The system shall be capable of using graphical and/or line application programming language for the Network Server Controllers.
14. Support For Open Systems Protocols
 - a. All Network Server Controllers must natively support the BACnet IP, BACnet MS/TP, LonWorks FTT-10, Modbus TCP, Modbus RTU (RS-485 and RS-232), and Modbus ASCII protocols.

B. BMS Operator Workstation Hardware and Software

1. The operator workstation portion of the BMS shall consist of one or more full-powered configuration and programming workstations, and one or more web-based operator workstations. For this project provide a minimum of 10 concurrent operator users and/or 2 concurrent engineering users within the enterprise server.
2. The programming and configuration workstation software shall allow any user with adequate permission to create and/or modify any or all parts of the NSC and/or Enterprise Server database.
3. All configuration workstations shall be personal computers operating under the Microsoft Windows operating system. The application software shall be capable of communication to all Network Server Controllers and shall feature high-resolution color graphics, alarming, trend charting. It shall be user configurable for all data collection and data presentation functions.
4. A minimum of 1 workstation shall be allowed on the Ethernet network. In this client/server configuration, any changes or additions made from one workstation will automatically appear on all other workstations since the changes are accomplished to the databases within the NSC. Systems with a central database shall not be acceptable.
5. Enterprise Server Requirements
6. Enterprise hardware shall be a standard unmodified digital computer of modular design currently being manufactured. Server hardware shall meet the following minimum requirements:
 - a. Processor: 2.6 GHz minimum
 - b. Memory: 4GB minimum
 - c. Operating systems:
 - 1) Microsoft Windows 7 32-bit (Professional, Enterprise, or Ultimate)
 - 2) Microsoft Windows 7 64-bit (Professional, Enterprise, or Ultimate)
 - 3) Microsoft Windows 8.1 32-bit (Pro, Pro N, Enterprise, or Enterprise N)
 - 4) Microsoft Windows 8.1 64-bit (Pro, Pro N, Enterprise, or Enterprise N)

- 5) Microsoft Windows Server 2008 R2 64-bit (Standard, Enterprise, Datacenter, Web, or Itanium)
 - 6) Microsoft Windows Server 2012 R2 64-bit (Standard, Datacenter, Essentials, or Foundation)
 - 7) Microsoft Windows Server 2012 R2 64-bit (Standard, Datacenter, Essentials, or Foundation)
 7. Virus Protection Software shall consist of the project site's standard virus protection software complete with a virus definition update subscription.
 8. Microsoft .Net 4.5
 9. 10/100MBPS Ethernet NIC (2) / with automatic switchover and load sharing
 10. 250 GB hard disk
 11. RAID (Redundant Array of Inexpensive Disks) at level 5 (RAID-5)
 12. Serial port, parallel port, USB port
 13. DVD drive
 14. High resolution (minimum 1280 x 1024), 17" rack-mount LCD monitor
 15. Redundant fans
 16. Hot-swappable redundant power supplies
 17. Include cantilever shelf and all hardware required for mounting monitor drawer in two post rack.
 18. License agreement for all applicable software
- C. Report Server Requirements
1. Processor: 2.6 GHz minimum
 2. Memory: 8GB minimum
 3. Operating Systems:
 - a. Microsoft Windows 2008 R2 64-bit (Standard, Enterprise, Datacenter, Web, or Itanium)
 - b. Microsoft Windows 2012 64-bit (Standard)
 - c. Microsoft Windows 2012 R2 64-bit (Standard, Datacenter)
 4. SQL Versions:
 - a. Microsoft SQL Server 2008 R2 64-bit SP2 (Standard and Express with Advanced Services)
 - b. Microsoft SQL Server 2012 64-bit (Standard and Express with Advanced Services)
 5. Virus Protection Software shall consist of the project site's standard virus protection software complete with a virus definition update subscription.
 - a. Microsoft .Net 4.5
 - b. 500 GB hard disk
 - c. License agreement for all applicable software
- D. Administration/Programming Workstation Requirements
1. Processor: 2.0 GHz minimum
 2. Memory: 4GB minimum
 3. Operating systems:
 - a. Microsoft Windows 7 32-bit (Professional, Enterprise, or Ultimate)
 - b. Microsoft Windows 7 64-bit (Professional, Enterprise, or Ultimate)
 - c. Microsoft Windows 8.1 32-bit (Pro, Pro N, Enterprise, or Enterprise N)
 - d. Microsoft Windows 8.1 64-bit (Pro, Pro N, Enterprise, or Enterprise N)
 - e. Microsoft Windows Server 2008 R2 64-bit (Standard, Enterprise, Datacenter, Web, or Itanium)

- f. Microsoft Windows Server 2012 R2 64-bit (Standard, Datacenter, Essentials, or Foundation)
 - g. Microsoft Windows Server 2012 R2 64-bit (Standard, Datacenter, Essentials, or Foundation)
 - 4. Virus Protection Software shall consist of the project site's standard virus protection software complete with a virus definition update subscription.
 - 5. Microsoft .Net 4.5
 - 6. Latest version of Microsoft Office Professional
 - 7. Latest version of Adobe Acrobat
 - 8. 10/100MBPS Ethernet NIC
 - 9. 20 GB hard disk
 - 10. Serial port, parallel port, USB port
 - 11. DVD drive
 - 12. High resolution (minimum 1280 x 1024), 24" flat panel display
 - 13. Optical mouse and full function keyboard
 - 14. Audio sound card and speakers
 - 15. License agreement for all applicable software
- E. Web Based Workstation Requirements
 - 1. Any user on the network can access the system, using the following software:
 - a. Windows 2000/XP and above
 - b. Internet Explorer 8 and above
 - c. Firefox 4.0 (32-bit) and above
 - d. Java-enabled
- F. BMS Software
 - 1. System architecture shall be truly client server in that the workstation shall operate as the client while the NSCs shall operate as the servers. The client is responsible for the data presentation and validation of inputs while the server is responsible for data gathering and delivery.
 - 2. The workstation functions shall include monitoring and programming of all BMS controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.
 - 3. Programming of SDCUs shall be capable of being done either off-line or on-line from any operator workstation. All information shall be available in graphic or text displays stored at the NSC. Graphic displays shall feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the BMS. All operator functions shall be selectable through a mouse.
- G. User Interface:
 - 1. The BMS workstation software shall allow the creation of a custom, browser-style interface linked to the user when logging into any workstation. Additionally, it shall be possible to create customized workspaces that can be assigned to user groups. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface must be able to be configured to become a user's "PC Desktop" – with all the links that a user needs to run other applications. This, along with the Windows user security capabilities, will enable a system administrator to setup workstation accounts that not only limit

the capabilities of the user within the BMS software, but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shutdown the active alarm viewer and/or unable to load software onto the PC.

2. System shall be able to automatically switch between displayed metric vs. imperial units based on the workstation/webstations localization.
3. The BMS workstation/webstations shall be capable of multiple language display, including English, Spanish, German, French, Japanese, Italian, Finnish, Portuguese, Swedish, Russian and traditional and simplified Chinese. The multiple languages shall not require add-on software from the standard workstation installer and shall be selectable within said workstation.
4. Webstations shall have the capability to automatically re-direct to an HTTPS connection to ensure more secure communications.
5. Personalized layouts and panels within workstations shall be extended to webstations to ensure consistent user experience between the two user interfaces.
6. Servers and clients shall have the ability to be located in different time zones, which are then synchronized via the NTP server.

H. User Security

1. The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall range from View only, Acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. The system must allow a minimum of 256 users to be configured per workstation. Additionally, the software shall enable the ability to add/remove users based upon Microsoft Windows Security Domains that enable the customer IT department to assist in user access.

I. Configuration Interface

1. The workstation software shall use a familiar Windows Explorer□-style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a “network map” of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure. All object names shall be alphanumeric and use Windows long filename conventions.
2. The configuration interface shall also include support for user defined object types. These object types shall be used as building blocks for the creation of the BMS database. They shall be created from the base object types within the system input, output, string variables, setpoints, etc., alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of user defined object types shall be able to be set up as a predefined aggregate of subsystems and systems. The configuration interface shall support copying/pasting and exporting/importing portions of the database for additional efficiency. The system shall also maintain a link to all “child” objects created. If a user wishes to make a change to a parent object, the software shall ask the user if he/she wants to update all of the child objects with the change.

J. Color Graphic Display Screens

1. The system shall allow for the creation of user defined, color graphic display screens for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse.
2. Requirements of the color graphic display screens include:
 - a. At a minimum, the user shall have the ability to import .gif, .png, .bmp, .jpeg, .tif, and CAD generated picture files as background displays, and layering shall be possible.
 - b. The system shall support both Java and HTML5 enabled graphics.
 - c. It shall be possible for the user to use JavaScript to customize the behavior of each graphic.
 - d. The editor shall use Scalable Vector Graphics (SVG) technology.
 - e. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, and graphs which can be “dropped” on a graphic through the use of a software configuration “wizard”. These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels.
 - f. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.
 - g. Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.
 - h. Ability to link graphic display screens through user defined objects, alarm testing, or the result of a mathematical expression. Operators must be able to change from one graphic display screen to another by selecting an object with a mouse - no menus will be required.
 - i. It shall be possible to create and save graphic display screen components and JavaScript code in reusable and transferrable, customized libraries.
 - j. Graphic display screens should rescale based on whatever monitor or viewing device is being used.
 - k. Be able to create graphic display screens on varying layers that can be moved and repeated.
 - l. Be able to create graphic display screens within varying window panes that can be moved and/or re-referenced. For example, creating the graphical menu within a pane and referencing it on every graphic display screen, therefore not rebuilding thus allowing for a single spot for updates that get pushed to all the pages that reference it.
3. Additionally, the graphics editor portion of the engineering software shall provide the following capabilities:
 - a. Create and save graphic display screens.
 - b. Group and ungroup symbols.
 - c. Modify an existing symbol.
 - d. Modify an existing graphic display screen.
 - e. Rotate and mirror a symbol.
 - f. Place a symbol on a graphic display screen.
 - g. Place analog dynamic data in decimal format on a graphic display screen.
 - h. Place binary dynamic data using state descriptors on a graphic display screen.

- i. Create motion through the use of animated .gif files or JavaScript.
- j. Place test mode indication on a graphic display screen.
- k. Place manual mode indication on a graphic display screen.
- l. Place links using a fixed symbol or flyover on a graphic display screen.
- m. Links to other graphic display screens
- n. Links to web sites
- o. Links to notes
- p. Links to time schedules
- q. Links to any .exe file on the operator workstation
- r. Links to .doc files
- s. Assign a background color.
- t. Assign a foreground color.
- u. Place alarm indicators on a graphic display screen.
- v. Change symbol/text/value color as a function of an analog variable.
- w. Change a symbol/text/value color as a function of a binary state.
- x. Change symbol/text/value as a function of a binary state.
- y. All symbols used in the creation of graphic display screens shall be saved to a library file for use by the owner.

K. Automatic monitoring

- 1. The software shall allow for the automatic collection of data and reporting from any controller or NSC. The frequency of data collection shall be user-configurable.

L. Alarm Management

- 1. The software shall be capable of accepting alarms directly from NSCs or controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software. Any alarm (regardless of its origination) will be integrated into the overall alarm management system and will appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphic display screens, or reports.
- 2. Alarm management features shall include:
 - a. A minimum of 1000 alarm notification levels. Each notification level will establish a unique set of parameters for controlling alarm display, distribution, acknowledgment, keyboard annunciation, and record keeping. Each notification level will establish a unique set of parameters for controlling alarm display, distribution, acknowledgement, keyboard annunciation, and record keeping.
 - b. Automatic logging in the database of the alarm message, point name, point value, source device, timestamp of alarm, username and time of acknowledgement, username and time of alarm silence (soft acknowledgement)
 - c. Playing an audible sound on alarm initiation or return to normal.
 - d. Sending an email page to anyone specifically listed on the initial occurrence of an alarm. The ability to utilize email paging of alarms shall be a standard feature of the software integrated with the operating system's mail application interface (MAPI). No special software interfaces shall be required and no email client software must be running in order for email to be distributed. The email notification shall be able to be sent to an individual user or a user group.

- e. Individual alarms shall be able to be re-routed to a user at user-specified times and dates. For example, a critical high temp alarm can be configured to be routed to a Facilities Dept. workstation during normal working hours (7am-6pm, Mon-Fri) and to a Central Alarming workstation at all other times.
- f. An active alarm viewer shall be included which can be customized for each user or user type to hide or display any alarm attributes.
- g. The active alarm viewer can be configured such that an operator must type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms.
- h. The active alarm viewer can be configured such that an operator must type in text in an alarm entry and/or pick from a drop-down list of causes for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.
- i. The active alarm viewer can be configured such that an operator must confirm that all of the steps in a check list have been accomplished prior to acknowledging the alarm.
- j. An operator shall have the capability to assign an alarm to another user of the system.
- k. Time schedules shall be able to be used to set control notifications to users.

M. Report Generation

- 1. The Reports Server shall be able to process large amounts of data and produce meaningful reports to facilitate analysis and optimization of each installation.
- 2. Reports shall be possible to generate and view from the operator workstation, and/or webstation, and/or directly from a reports-only web interface.
- 3. A library of predefined automatically generated reports that prompt users for input prior to generation shall be available. The properties and configurations made to these reports shall be possible to save as Dashboard reports, so that the configurations are saved for future used.
- 4. It shall be possible to create reports standard tools, such as Microsoft Report Builder 2.0 or Visual Studio, shall be used for customized reports.
- 5. Additional reports or sets of reports shall be downloadable, transferrable, and importable
- 6. All reports shall be able to be set up to automatically run or be generated on demand.
- 7. Each report shall be capable of being automatically emailed to a recipient in Microsoft Word, Excel, and/or Adobe .pdf format.
- 8. Reports can be of any length and contain any point attributes from any controller on the network.
- 9. Image management functionality shall be possible to enable the system administrators to easily upload new logos or images to the system.
- 10. It shall be possible to run other executable programs whenever a report is initiated.
- 11. Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.
- 12. Minimum supplied reports shall include:
 - a. Activities Per Server Report
 - b. Activities Per User Report
 - c. Alarm Amount by Category Report
 - d. Alarm Amount by Type Report
 - e. Alarms Per Server Report

- f. Current Alarm Report
 - g. Most Active Alarm Report
 - h. System Errors Per Server Report
 - i. Top Activities Report
 - j. Top Alarms Report
 - k. Top System Errors Report
 - l. Trend Log Comparison Report
 - m. User Logins Report
 - n. Users and Groups Reports
 - o. Override Report: Points overridden, including time overridden, and identification of operator overriding the point
 - p. Run Time Reports: A report totalizing the accumulated run time of individual pieces of equipment. The end user shall be able define equipment groupings and shall be able to generate reports based on these groupings.
 - q. Chiller Usage Report: A report of the operation of each chiller on a daily and monthly basis, including:
13. Total on-time for each level for the current month
- a. Cooling Tower Profiles: A cooling tower profile for each cooling tower, including:
 - 1) Total daily and monthly on-time (each fan)
 - 2) Number of on and off transitions (each fan)
 - 3) Maximum and minimum daily condenser water temperature and the time of occurrence for the current and previous months
14. Minimum Energy Reports shall include:
- a. Energy Monitoring Calendar Consumption Report: Shall provide an interactive report that shows the energy usage on one or multiple selected days
 - b. Energy Monitoring Consumption Breakdown Report: Shall provide a report on energy consumption broken down using sub-metering
 - c. Energy Monitoring Consumption Report: Shall show the energy consumption against a specified target value
 - d. LEED Measurement & Verification (M&V) Report: Full listing of all data points designated for M&V over a user definable one year period of time.
15. . Provide allowance for ten (10) additional end-user defined custom reports.

N. Scheduling

- 1. From the workstation or webstation, it shall be possible to configure and download schedules for any of the controllers on the network.
- 2. Time of day schedules shall be in a calendar style and viewable in both a graphical and tabular view.
- 3. Schedules shall be programmable for a minimum of one year in advance.
- 4. To change the schedule for a particular day, a user shall simply select the day and make the desired modifications.
- 5. Additionally, from the operator webstations, each schedule will appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.
- 6. Schedules will be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation will be automatically updated to the corresponding schedule in the controller.

7. It shall be possible to assign a lead schedule such that shadow/local schedules are updated based upon changes in the Lead.
8. It shall be possible to assign a list(s) of exception event days, dates, date ranges to a schedule.
9. It shall be possible to view combined views showing the calendar and all prioritized exemptions on one screen.
10. It should accommodate a minimum of 16 priority levels.
11. Values should be able to be controlled directly from a schedule, without the need for special program logic.

O. Programmer's Environment

1. Programming in the NSC shall be either in graphical block format or line-programming format or both.
2. Programming of the NSC shall be available offline from system prior to deployment into the field. All engineering tasks shall be possible, except, of course, the viewing of live tasks or values.
3. The programmer's environment will include access to a superset of the same programming language supported in the SDCUs.
4. NSC devices will support both script programming language as well as the graphical function block programming language. For both languages, the programmer will be able to configure application software for custom program development, and write global control programs. Both languages will have debugging capabilities in their editors.
5. It shall be possible to save custom programs as libraries for reuse throughout the system. A wizard tool shall be available for loading programs from a library file in the program editor.
6. It shall be possible to view graphical programming live and real-time from the workstation.
7. The system shall be capable of creating 'binding templates' allowing the user to bind multiple points to multiple objects all at once.
8. Key terms should appear when typing (IntelliType).
9. Applications should be able to be assigned different priorities and cycle times for a prioritized execution of different function.
10. The system shall be able to create objects that allow common objects such as power meters, VFD drives, etc. to be integrated into the system with simple import actions without the need of complicated programming or configuration setups.

P. Saving/Reloading

1. The workstation software shall have an application to save and restore NSC and field controller memory files.
2. For the NSC, this application shall not be limited to saving and reloading an entire controller – it must also be able to save/reload individual objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.

Q. Audit Trail

1. The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.

2. It shall be possible to view a history of alarms, user actions, and commands for any system object individually or at least the last 5000 records of all events for the entire system from the workstation.
 3. It shall be possible to save custom filtered views of event information that are viewable and configurable in the workstation.
 4. It shall be capable to search and view all forced values within the system.
- R. Fault Tolerant Enterprise Server Operation (Top level NSC)
1. A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switchover.
- S. BACnet Object Browser
1. This software shall be capable of fully browsing, discovering, and displaying in a tree-view structure all BACnet devices on the network. The BACnet object browser shall also be capable of reading and writing (where supported by the remote device) any property of any object of any device on the network.
- T. Web-based Operator Software
1. General
 - a. Day-to-day operation of the system shall be accessible through a standard web browser interface, allowing technicians and operators to view any part of the system from anywhere on the network.
 - b. The system shall be able to be accessed on site via a mobile device environment with, at a minimum, access to overwrite and view system values.
 2. Graphic Display Screens
 - a. The browser-based interface must share the same graphic display screens as the administration and programming workstations, presenting dynamic data on site layouts, floor plans, and equipment graphic display screens. The browser's graphic display screens shall support commands to change setpoints, enable/disable equipment and start/stop equipment.
 - b. Through the browser interface, operators must be able to navigate through the entire system, and change the value or status of any point in any controller. Changes are effective immediately to the controller, with a record of the change stored in the system database.
 3. Alarm Management
 - a. Systems requiring additional client software to be installed on a PC for viewing the webstation from that PC will not be considered.
 - b. Through the browser interface, a live alarm viewer identical to the alarm viewer on the Administration and Programming workstation shall be presented, if the user's password allows it. Users must be able to receive alarms, silence alarms, and acknowledge alarms through a browser. If desired, specific operator text must be able to be added to the alarm record before acknowledgement, attachments shall be viewable, and alarm checklists shall be available.
- U. Groups and Schedules
1. Through the browser interface, operators must be able to view pre-defined groups of points, with their values updated automatically.

2. Through the browser interface, operators must be able to change schedules – change start and stop times, add new times to a schedule, and modify calendars.
- V. User Accounts and Audit Trail
1. The same user accounts shall be used for the browser interface and for the operator workstations. Operators must not be forced to memorize multiple passwords.
 2. All commands and user activity through the browser interface shall be recorded in the system's activity log, which can be later searched and retrieved by user, date, or both.
- W. Web Services
1. The installed system shall be able to use web services to “consume” information within the Network Server/Controllers (NSCs) with other products and systems. Inability to perform web services within the NSCs will be unacceptable.
 - a. Shall be able to “consume” data into the system via SOAP and REST web services.
 - b. Shall be able to “serve” and “consume” data from other Schneider Electric systems such as StruxureWare Data Center Expert & StruxureWare Power Monitoring Expert.
- X. Embedded Power and Energy Management Software
1. General Description
 - a. The Embedded Power and Energy Management Software (Embedded PEMS) shall be a web-enabled monitoring system intended to monitor an entire electrical distribution infrastructure, from incoming utility feeds down to low voltage distribution points.
 - b. Embedded PEMS shall be designed to monitor and manage energy consumption throughout an enterprise, whether within a single facility or across a network of facilities, to improve energy availability and reliability, and to measure and manage energy efficiency.
 - c. Embedded PEMS shall be a standard product offering with no custom programming required.
 - d. Key features shall include:
 - 1) Tools for integrating data and user web applications into StruxureWare Building Operation software
 - 2) Data acquisition for metering devices, sensors, and other intelligent electric devices
 - 3) Power Quality analysis (including harmonics, voltage sags/swells, transients and voltage and current sinusoids)
 - 4) Interactive and user configurable dashboards using drag and drop display gadgets
 - 5) Automated dashboard slideshows
 - 6) Reporting engine with user configurable report templates and automated report distribution capabilities
 - 7) Water, Air, Gas, Electricity, Steam (WAGES) monitoring and reporting
 - 8) Power Factor monitoring and reporting
 - 9) Interoperability with disparate devices and systems through OPC DA 2.01 Client and Server

- 10) Web Services interface for sharing data with other systems and applications (via Web Services Description Language [WSDL] using Simple Object Access Protocol [SOAP] messages)
 - 11) Third Party Device Integration through Modbus RTU and Modbus TCP protocols
2. Software Description
 - a. The Embedded Power and Energy Management Software (Embedded PEMS) shall provide a seamless user experience (“single pane of glass”) for managing the mechanical systems (HVAC, etc) and monitoring the power distribution system (transformers, breakers, relays, switches, power meters, UPS, ATS, invertors, generators, capacitors etc.).
 - b. The End User/ Software Operator shall not have to launch or log into a separate Power Monitoring application, but rather can access all Power Management applications and information from the BMS software interfaces.
 - c. Embedded PEMS shall come with factory System Integration Tools that ensure a rapid and standardized integration of the data and the web applications into the BMS.
 3. Device Support
 - a. Embedded PEMS shall provide factory-tested, built-in support for at least 50 electrical distribution devices (energy and power meters, protection relays, circuit breakers, PLCs, etc.).
 - b. Embedded PEMS device support shall be comprehensive and will include:
 - 1) ready-to-go, pre-engineered, interactive graphical display screens for viewing and analyzing real-time and historical device data
 - 2) all registers pre-mapped to standard measurement names such that no additional mapping of internal device registers is required to use any feature of Embedded PEMS.
 - 3) automatic upload of timestamped onboard data logs, event strings, and waveform captures to Embedded PEMS without any configuration.
 4. Electrical System Health Screens
 - a. Embedded PEMS shall have simple, graphical, real-time views of the electrical distribution system for the purposes of monitoring:
 - 1) Voltage (designated phase or 3-phase average for Line-to-Line or Line-to-Neutral)
 - 2) Current (designated phase or 3-phase average)
 - 3) Power (Active Power 3-Phase Total [kW])
 - 4) Power Factor (Signed Total or designated PF lagging)
 - b. The Electrical System Health Screens shall be comprised of programmable, TGML graphical components that support the following functions:
 - 1) Real-time numeric display of the present value
 - 2) Zoom in View (when mouse hovers over graphical component)
 - 3) Graphical components change color based on programmable thresholds
 - 4) Graphical components support a minimum of 4 programmable thresholds
 - c. Every Electrical System Health Screen shall contain a parameter selector component that allows a user to change the real-time monitoring parameter (Voltage, Current, Power, Power Factor) shown in all of the graphical

- components on the screen with a single mouse click, thus updating the entire screen at once.
5. Electrical Single-Line / One-Line Symbol Library
 - a. Embedded PEMS shall come equipped with a factory graphics electrical symbol library for:
 - 1) ANSI electrical one-line symbols
 - 2) IEC electrical single-line symbols
 6. Embedded Dashboard Application
 - a. Embedded PEMS shall have a web client interface that presents interactive, auto-updating dashboard views that may contain WAGES energy summary data, historical data trends, images and content from any accessible URL address.
 - b. Users shall be able to create, modify, view and share their dashboards (including graphics, labels, scaling, measurements, date ranges, etc.) from within the web-based application using only a browser and without the need for a separate software application.
 - c. Dashboards may be easily created with configurable “drag & drop” Gadgets to show the following views:
 - 1) Images from any web-based content
 - 2) Energy Consumption
 - 3) Energy Cost
 - 4) Energy Comparison
 - 5) Energy Savings
 - 6) Emissions
 - 7) Trends
 - 8) Energy Equivalency (with updated values and user-selected graphics)
 - d. Embedded PEMS shall allow individual “Dashboards” to be assigned to “Slideshows” that may run unattended, scrolling through the designated Dashboards at a configurable interval of time.
 - e. Embedded PEMS shall allow an unlimited number of Dashboards and Slideshows to be created, saved and shared by any User of the system.
 7. Embedded Report Application
 - a. Embedded PEMS shall provide a web-enabled reporting tool to view historical data in pre-formatted or user-defined report templates.
 - b. Users shall be able to create, modify, view and share their reports in the web reports interface.
 - c. The reporting tool shall provide standard pre-formatted report templates as follows:
 - 1) Billing Report
 - 2) Energy Cost Report
 - 3) Load Profile Report
 - 4) System-wide interactive Power Quality with CBEMA/ITIC evaluation
 - 5) Energy Period Over Period Report
 - 6) Energy Use by Shift Report
 - 7) Tabular Report
 - 8) Trend Report
 - 9) System Configuration Report
 - 10) Hourly Usage Report
 - 11) Single Device Usage Report

- 12) Multi Device Usage Report
- 13) Energy by Time of Use Report
- 14) Energy Usage Report
- 15) Energy Comparison Report
- 16) Consumption Ranking Report
- d. The reporting tool shall directly support the following output formats:
 - 1) HTML
 - 2) PDF
 - 3) TIFF
 - 4) Excel
 - 5) XML
- e. The reporting tool shall provide the ability to create report “Subscriptions” to facilitate the automatic distribution of reports according to a schedule. Reports may be saved to a network location, printed or emailed.
- 8. Application Logic Engine
 - a. Embedded PEMS shall provide a graphical, object-oriented programming interface for creating system-wide, logical programs with arithmetic, XML data import, PC-based alarming and logging capabilities.
 - b. The application logic engine shall have a comprehensive set of functions such that deployment engineers may create custom applications programs such as weather or real-time price import, KPI calculations, energy units conversion, data aggregation, data normalization, data comparison, power loss calculations, power factor control, load shedding, etc.
- 9. Logic Devices
 - a. Embedded PEMS shall support “Logical” device definitions that provide user-friendly device and measurement names for inputs/outputs or channels on devices that represent a downstream device (in the case of PLCs and auxiliary inputs) or an individual circuit (in the case of multi-circuit devices).
 - b. A system deployment engineer shall be able to use a simple, structured file (containing logical device mappings and names) for the purpose of creating large numbers of logical devices in the system (bulk configuration) WITHOUT the need to configure each logical device manually.
- 10. Hierarchies
 - a. Embedded PEMS shall support the concept of hierarchies such that historical data can be organized according to the domain of the Customer’s industry. For example, a campus could organize their hierarchies as Campus/Building/Area/Floor/Room or Campus/Building/LoadType etc.
 - b. Embedded PEMS shall have the ability to track Hierarchy configuration changes over time and allow administrators to update the names in a given hierarchy at any time (even in the past) to ensure accurate reporting of associated data points. For example, report on energy consumption for a tenant who has re-located, expanded, added or removed circuits during the billing period.
- 11. Modbus Interoperability
 - a. Embedded PEMS shall have advanced communication capabilities for supporting Modbus communicating devices. Embedded PEMS shall function as a Modbus master with the ability to read from and write to registers in Modbus devices for monitoring and control applications.

- b. Embedded PEMS shall provide an application that is designed for system deployment engineers for creating Modbus device definitions (device drivers) so that 3rd party devices that support Modbus protocol may be easily integrated into the PEMS system.
- 12. OPC (Ole for Process Control) Interoperability
 - a. Embedded PEMS shall be OPC DA 2.0.1 compliant (as per the OPC Foundation Compliance Testing process) for OPC Server and OPC Client data sharing applications amongst OPC compliant systems.
 - b. Embedded PEMS shall provide default OPC Server tag mappings for all of its natively supported device types WITHOUT the need to select, configure or program the mapping of device registers to OPC tags.
 - c. Embedded PEMS shall provide a flexible means to add or change OPC mappings and shall support the ability to add custom measurements.
- 13. Extract, Transform, and Load (ETL) Engine
 - a. Embedded PEMS shall support Extract, Transform and Load (ETL) data log file transfer mechanisms. It will be able to import data log files into its historical database and export data log files from its historical database for system data sharing and file transfer applications (e.g. manual data entry, offline device data import, push data to the cloud or 3rd party system, etc.).
 - b. Embedded PEMS shall provide an ETL application that is designed for system deployment engineers for establishing log data file import-export mappings and schedules so that historical data can be incorporated into or exported from the power monitoring system via file transfer (.csv, .xml, etc.).
- 14. Web Services for Software Integration
 - a. Embedded PEMS shall provide a Web Services interface for machine-to-machine interactions with other application software systems. The web service interface shall have the following characteristics:
 - 1) Based on SOAP (Simple Object Access Protocol) protocol specification
 - 2) Provide a Web Services Description Language (WSDL) based, machine-readable description
 - 3) Allow access to real-time, historical (i.e. time stamped), and alarm/event type data
 - 4) Provide the ability to acknowledge alarms by authenticated and authorized clients
 - 5) Provide digest authentication functionality
 - 6) Provide the ability to be enabled/disabled
 - b. Embedded PEMS shall be designed to easily integrate into Schneider Electric EcoStruxure solutions such as SmartStruxure solution.
- 15. Communications Sub-systems
 - a. Embedded PEMS shall support multiple communications network topologies including Ethernet/TCP, serial RS-485/RS-232, and Modem dial-up connections.
 - b. Embedded PEMS shall have the capability to provide time-synchronization signals over an Ethernet network with 16ms accuracy.
 - c. Embedded PEMS shall have the capability to communicate simultaneously with multiple devices, including devices that are on different physical communications channels.
 - d. Embedded PEMS shall scale to communicate from 1 to 1000's of devices.

- e. Embedded PEMS shall have the ability to retrieve logged data (interval data, event data, waveform data) from natively supported devices in the system automatically WITHOUT any configuration (of upload jobs, log tasks, etc).
- f. Embedded PEMS shall have the ability to accept or reject duplicate data entries into the database.
- 16. Offline Configuration
 - a. Embedded PEMS shall support the ability to develop custom graphics screens and application logic programs using device register map files EVEN WHEN DEVICES ARE OFFLINE / DISABLED so that application engineers and HMI design engineers can develop customer projects easily without having to be connected to live devices.
- 17. Data Storage
 - a. Embedded PEMS shall be designed to use Microsoft SQL Server for its database engine and data storage.
 - b. Embedded PEMS shall support having the database engine installed on the same computer or a separate dedicated Database Server computer.
 - c. Embedded PEMS shall include a “default” database engine option (e.g. SQL Server Express Edition) with its media. During the installation of Embedded PEMS, if the “default” database engine option is selected, it shall be installed by Embedded PEMS installer WITHOUT having to acquire and install it separately.
- 18. System Administration
 - a. Embedded PEMS shall provide a comprehensive Administrative interface for power users or system deployment engineers that supports the following functions::
 - 1) Configure connection schedules and manage modem connections
 - 2) Add devices to the system and manage their communication settings
 - 3) View and manage software system events
 - 4) Administer database management tasks (backup, archiving and trimming)
 - b. Embedded PEMS shall provide a comprehensive Administrative interface for power users or system deployment engineers that supports the following functions:
 - 1) adding, modifying or removing devices in the system
 - 2) creating, modifying or removing graphical diagrams, dashboards, tables, reports
 - 3) creating, modifying or removing application logic programs in the Application Logic Engine

Y. Network Server Controllers (NSCs)

- a. Network Router Controllers shall combine both network routing functions, control functions, and server functions into a single unit.
 - 1) The BACnet NSC shall be classified as a “native” BACnet device, supporting the BACnet Network Server Controller (B-BC) profile. Controllers that support a lesser profile such as B-SA are not acceptable. NSCs shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Network Server Controllers (B-BC).

- 2) The Network Server Controller shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NRS.
 - 3) The NSCs shall be capable of whitelisting IPs to restrict access to a pre-defined list of hosts or devices.
 - 4) They shall also be responsible for monitoring and controlling their own HVAC equipment such as an AHU or boiler.
 - 5) They shall also contain graphics, trends, trend charts, alarm views, and other similar presentation objects that can be served to workstations or web-based interfaces. A sufficient number of NSCs shall be supplied to fully meet the requirements of this specification and the attached point list.
 - 6) It shall be capable of executing application control programs to provide:
 - a) Calendar functions
 - b) Scheduling
 - c) Trending
 - d) Alarm monitoring and routing
 - e) Time synchronization by means of an Internet site including automatic synchronization
 - f) Native integration of LonWorks controller data and Modbus controller data or BACnet controller data and Modbus controller data
 - g) Network Management functions for all LonWorks based devices
 - h) Hardware Specifications
 - 7) Memory:
 - a) The operating system of the controller, application programs, and all other portions of the configuration database, shall be stored in non-volatile, FLASH memory. Servers/Controllers shall contain enough memory for the current application, plus required history logging, plus a minimum of 20% additional free memory.
 - b. Each NRC shall provide the following on-board hardware for communication:
 - 1) One 10/100bT Ethernet for communication to workstations, other NRCs and onto the Internet
 - 2) Two RS-485 ports for communication to BACnet MS/TP bus or serial Modbus (software configurable)
 - 3) One TP/FT port for communication to LonWorks devices.
 - 4) One Device USB port
 - 5) Two host USB Ports
19. The NSC shall conform to a small footprint no larger than 3.94W x 4.92H x 2.95D inches.
- a. Modular Expandability:
 - 1) The system shall employ a modular I/O design to allow expansion. Input and output capacity is to be provided through plug-in modules of various types. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.

- 2) One shall be able to “hot-change” (hot-swap) the I/O modules preserving the system on-line without any intervention on the software; addressing and configuration shall be automatic.
 - 3) If for any reason the backplane of the modular I/O system were to fail, I/O module addresses will be protected.
- b. Hardware Override Switches:
- 1) All digital outputs shall, optionally, include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position. For large equipment such as AHUs, Supply Fans, Exhaust Fans, and Pumps, digital outputs must have this capability.
- c. Universal Input Temperatures
- 1) All universal inputs directly connected to the NSC via modular expansion shall be capable of using the following thermistors for use in the system without any external converters needed.
 - a) 10 kohm Type I (Continuum)
 - b) 10 kohm Type II (I/NET)
 - c) 10 kohm Type III (Satchwell)
 - d) 10 kohm Type IV (FD)
 - e) Linearized 10 kohm Type V (FD w/11k shunt)
 - f) Linearized 10 kohm (Satchwell)
 - g) 1.8 kohm (Xenta)
 - h) 1 kohm (Balco)
 - i) 20 kohm (Honeywell)
 - j) 2.2 kohm (Johnson)
 2. In addition to the above, the system shall be capable of using the below RTD sensors, however it is not required that all universal inputs be compatible with them.
 - a) PT100 (Siemens)
 - b) PT1000 (Sauter)
 - c) Ni1000 (Danfoss)
- d. Local Status Indicator Lamps:
- 1) The NSC shall provide as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status. For each input or output, provide LED indication of the value of the point (On/Off). The LED indication shall support software configuration to set whether the illumination of the LED corresponds to On or Off or whether the color when illuminated is Red or Green.
- e. Real Time Clock (RTC):
- 1) Each NSC shall include a battery-backed, real time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. Each NSC will allow for its own UTC offset, depending upon the time zone. When the time zone is set, the NSC will also store the appropriate times for daylight savings time.

- f. Power Supply:
 - 1) The 24 VDC power supply for the NSCs shall provide 30 watts of available power for the NSC and associated IO modules. The system shall support the use of more than one power supply if heavily power consuming modules are required.
 - 2) The power supply, NSC, and I/O modules shall connect power wise and communication wise via the separate terminal base allowing for ease of replacement and no separate or loose wiring.
- g. Automatic Restart After Power Failure:
 - 1) Upon restoration of power after an outage, the NSC shall automatically and without human intervention update all monitored functions, resume operation based on current, synchronize time and status, and implement special start-up strategies as required.
- h. Battery backup:
 - 1) The NSC shall include an on-board battery to back up the controller's RAM memory. The battery shall provide accumulated backup of all RAM and clock functions for at least 30 days. In the case of a power failure, the NSC shall first try to restart from the RAM memory. If that memory is corrupted or unusable, then the NSC shall restart itself from its application program stored in its FLASH memory.
- i. Software Specifications
 - 1) The operating system of the controller, application programs, and all other portions of the configuration database such as graphics, trends, alarms, views, etc., shall be stored in non-volatile, FLASH memory. There will be no restrictions placed on the type of application programs in the system. Each NSC shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.
 - 2) Each NSC shall have an available capacity of 4 GB of memory. This shall represent 2 GB for application and historical data and 2 GB dedicated for backup storage.
- j. User Programming Language:
 - 1) The application software shall be user programmable. This includes all strategies, sequence of operation, control algorithms, parameters, and setpoints. The source program shall be either a script-based structured text or graphical function block based and fully programmable by the user. The language shall be structured to allow for the configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, and histories. Users shall be able to place comments anywhere in the body of either script or function block programs.
 - 2) Network Server Controllers that use a "canned" program method will not be accepted.
- k. Control Software:

- 1) The NSC shall have the ability to perform the following pre-tested control algorithms:
 - a) Proportional, Integral plus Derivative Control (PID)
 - b) Two Position Control
 - c) Digital Filter
 - d) Ratio Calculator
 - e) Equipment Cycling Protection
- l. Mathematical Functions:
 - 1) Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These must be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.
- m. NSCs shall have the ability to perform any or all of the following energy management routines:
 - 1) Time of Day Scheduling
 - 2) Calendar Based Scheduling
 - 3) Holiday Scheduling
 - 4) Temporary Schedule Overrides
 - 5) Optimal Start
 - 6) Optimal Stop
 - 7) Night Setback Control
 - 8) Enthalpy Switchover (Economizer)
 - 9) Peak Demand Limiting
 - 10) Temperature Compensated Duty Cycling
 - 11) CFM Tracking
 - 12) Heating/Cooling Interlock
 - 13) Hot/Cold Deck Reset
 - 14) Hot Water Reset
 - 15) Chilled Water Reset
 - 16) Condenser Water Reset
 - 17) Chiller Sequencing
- n. History Logging:
 - 1) Each NSC controller shall be capable of LOCALLY logging any input, output, calculated value or other system variable either over user defined time intervals ranging from 1 second to 1440 minutes or based upon a user configurable change of value. A minimum of 1000 logs, with a minimum of 100,000 records, shall be stored. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logged data shall be downloadable to a higher level NSC long term archiving based upon user-defined time intervals, or manual command.
 - 2) For extended trend logging a minimum of 1500 trends shall be capable, with a minimum number of 600,000 records within.
 - 3) Management of a power meter replacement to ensure meter log data is accurate shall be possible in the NSC.
 - 4) Every hardware input and output point, hosted within the NSC and attached I/O modules, shall be trended automatically without the requirement for manual creation, and each of these logs shall log

- values based upon a change of value and store at least 500 trend samples before replacing the oldest sample with new data.
- 5) The presentation of logged data shall be built into the server capabilities of the NSC Presentation can be in time stamped list formats or in a chart format with fully configurable pen colors, weights, scales and time spans.
- p. Alarm Management:
- 1) For each system point, alarms can be created based on high/low limits or in comparison to other point values. All alarms will be tested each scan of the NSC and can result in the display of one or more alarm messages or reports.
 - 2) There is no limit to the number of alarms that can be created for any point
 - 3) Alarms can be configured to be generated based upon a single system condition or multiple system conditions.
 - 4) Alarms will be generated based on an evaluation of the alarm conditions and can be presented to the user in a fully configurable order, by priority, by time, by category, etc. These configurable alarm views will be presented to a user upon logging into the system regardless of whether the log in takes place at a workstation or a webstation.
 - 5) The alarm management system shall support the ability to create and select cause and action notes to be selected and associated with an alarm event. Checklists shall also be possible in order to present to an operator a suggested mode of troubleshooting. When acknowledging an alarm, it shall be possible to assign it to a user of the system such that the user is notified of the assignment and is made responsible for the alarm resolution.
 - 6) Alarms must be capable of being routed to any BACnet workstation that conforms to the B-OWS device profile and uses the BACnet/IP protocol.
- q. Embedded Web Server
- 1) Each NSC must have the ability to serve out web pages containing the same information that is available from the engineering workstation. The development of the screens to accomplish shall not require any additional engineering labor over that required to show them at the WorkStation itself.
20. BACnet Fieldbus and BACnet SDCUs
- a. Networking
 1. IP Network: All devices that connect to the WAN shall be capable of operating at 10 megabits per second or 100 megabits per second.
 2. IP To Field Bus Routing Devices
 - a) A Network Server Controller shall be used to provide this functionality.
 - b) These devices shall be configurable locally with IP crossover cable and configurable via the IP network.
 - c) The routing configuration shall be such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.
 - b. Field Bus Wiring and Termination

- 1) The wiring of components shall use a bus or daisy chain concept with no tees, stubs, or free topology.
- 2) Each field bus shall have a termination resistor at both ends of each segment.
- 3) The field bus shall support the use of wireless communications.
- c. Repeaters
 - 1) Repeaters are required to connect two segments.
 - 2) Repeaters shall be installed in an enclosure. The enclosure may be in an interstitial space.
- d. Field Bus Devices
 - 1) General Requirements
 - a) Devices shall have a light indicating that they are powered.
 - b) Devices shall be locally powered. Link powered devices (power is furnished from a central source over the field bus cable) are not acceptable.
 - c) Application programs shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration parameter settings. (Battery backup, flash memory, etc.)
- e. Network Server Controllers (NSCs)
 - 1) If NSCs have embedded I/O, all of the requirements for I/O that are described under Advance Application Controllers shall apply.
 - 2) Shall support the export of data to NSCs from other vendors that support the data sharing, read property service.
 - 3) Shall support the export of data using Change of Value (COV) initiation to NSCs from other vendors that support the subscription to data using the COV concept.
 - 4) Shall support the export of data to any BACnet OWS that supports the data sharing, read property service.
 - 5) Shall support the export of data using Change of Value (COV) initiation to any BACnet OWS that supports the subscription to data using the COV concept.
 - 6) Shall provide trend log support for all of the devices on the field bus. They shall provide sufficient memory to store up to 300 samples for each variable required to be trended by the sequence of control.
 - 7) Shall support the exporting of trend log data to any BACnet OWS that supports the read range BACnet service for trending.
 - 8) Shall provide time schedule support for all of the devices on the field bus.
 - 9) Shall support the editing of time schedule entries from any BACnet OWS that supports the BACnet service for writing of time schedule parameters.
 - 10) Shall provide alarm message initiation for all alarms conditions from any of the field bus devices.
 - 11) Shall deliver alarm messages to any BACnet OWS that supports the BACnet service for receiving alarm messages and is configured to be a recipient of the notification.

- 12) Shall support alarm acknowledgement from any BACnet OWS that supports the BACnet service for executing alarm/event acknowledgement.
 - 13) Shall support the control of the out of service property and assignment of value or state to analog and binary objects from any BACnet OWS that supports writing to the out of service property and the value property of analog and binary objects.
 - 14) Shall support the receipt and response to Time Synchronization commands from any device that supports the BACnet service for initiating time synchronization commands.
 - 15) Shall support the "Who is?" and "I am." BACnet service.
 - 16) Shall support the "Who has?" and "I have." BACnet service.
 - 17) Shall support Backup and Restore commands from any BACnet OWS that supports the initiation of Backup and Restore commands.
 - 18) Shall be BTL certified.
- f. Advance Application Controllers (B-AAC)
- 1) The key characteristics of a B-AAC are:
 - a) They have physical input and output circuits for the connection of analog input devices, binary input devices, pulse input devices, analog output devices, and binary output devices. The number and type of input and output devices supported will vary by model.
 - b) They may or may not provide support for additional input and output devices beyond the number of circuits that are provided on the basic circuit board. Support for additional I/O shall be provided by additional circuit boards that physically connect to the basic controller.
 - c) The application to be executed by a B-AAC is created by an application engineer using the vendor's application programming tool.
 - d) If local time schedules are embedded, the B-AAC shall support the editing of time schedule entries from any BACnet OWS that supports the BACnet service for writing of time schedule parameters.
 - e) If local trend logging is embedded, the B-AAC shall support the exporting of trend log data to any BACnet OWS that supports the read range BACnet service for trending.
 - f) If local alarm message initiation is embedded, the B-AAC shall:
 - 2) Deliver alarm messages to any BACnet OWS that supports the BACnet service for receiving alarm messages and is configured to be a recipient of the alarm message.
 - 3) Support alarm acknowledgement from any BACnet OWS that supports the BACnet service for executing alarm/event acknowledgement.
 - a) Shall support the reading of analog and binary data from any BACnet OWS or Building Controller that supports the BACnet service for the reading of data.

- b) Shall support the control of the out of service property and assignment of value or state to analog and binary objects from any BACnet OWS that supports writing to the out of service property and the value property of analog and binary objects.
 - c) Shall support the receipt and response to Time Synchronization commands from a BACnet Building Controller.
 - d) Shall support the “Who is” and “I am.” BACnet services.
 - e) Shall support the “Who has” and “I have.” BACnet services.
- g. Analog Input Circuits
 - 1) The resolution of the A/D chip shall not be greater than 0.01 Volts per increment. For an A/D converter that has a measurement range of 0 to 10 VDC and is 10 bit, the resolution is 10/1024 or 0.00976 Volts per increment.
 - 2) For non-flow sensors, the control logic shall provide support for the use of a calibration offset such that the raw measured value is added to the (+/-) offset to create a calibration value to be used by the control logic and reported to the operator workstation (OWS).
 - 3) For flow sensors, the control logic shall provide support for the use of an adjustable gain and an adjustable offset such that a two point calibration concept can be executed (both a low range value and a high range value are adjusted to match values determined by a calibration instrument).
 - 4) For non-linear sensors such as thermistors and flow sensors the B-AAC shall provide software support for the linearization of the input signal.
- h. Binary Input Circuits
 - 1) Dry contact sensors shall wire to the controller with two wires.
 - 2) An external power supply in the sensor circuit shall not be required.
- i. Pulse Input Circuits
 - 1) Pulse input sensors shall wire to the controller with two wires.
 - 2) An external power supply in the sensor circuit shall not be required.
 - 3) The pulse input circuit shall be able to process up to 20 pulses per second.
- j. True Analog Output Circuits
 - 1) The logical commands shall be processed by a digital to analog (D/A) converter chip. The 0% to 100% control signal shall be scalable to the full output range which shall be either 0 to 10 VDC, 4 to 20 milliamps or 0 to 20 milliamps or to ranges within the full output range (Example: 0 to 100% creates 3 to 6 VDC where the full output range is 0 to 10 VDC).
 - 2) The resolution of the D/A chip shall not be greater than 0.04 Volts per increment or 0.08 milliamps per increment.
- k. Binary Output Circuits
 - 1) Single pole, single throw or single pole, double throw relays with support for up to 230 VAC and a maximum current of 2 amps.

- 2) Voltage sourcing or externally powered triacs with support for up to 30 VAC and 0.5 amps at 24 VAC.
- 3) For large equipment such as AHUs, Supply Fans, Exhaust Fans, and Pumps, digital outputs must have built-in HAND / OFF / AUTO switches.
- l. Program Execution
 - 1) Process control loops shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
 - 2) The sample rate for a process control loop shall be adjustable and shall support a minimum sample rate of 1 second.
 - 3) The sample rate for process variables shall be adjustable and shall support a minimum sample rate of 1 second.
 - 4) The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
 - 5) The application shall have the ability to determine if a power cycle to the controller has occurred and the application programmer shall be able to use the indication of a power cycle to modify the sequence of controller immediately following a power cycle.
- m. Local Interface
 - 1) The controller shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:
 - a) Adjust application parameters
 - b) Execute manual control of input and output points
 - c) View dynamic data
21. BACnet Room Controller
 - a. General Description
 - 1) The room controller shall be a BACnet MS/TP device capable of on/off, three point floating, or 0-10Vdc analog) control of a VAV damper actuator, two-pipe heating and/or cooling application, or four-pipe heating and cooling applications, as well as auxiliary reheat.
22. Controller shall be equipped with a TFT transmissive LED-backlit LCD touch screen with a 70.08 mm x 52.56 mm active area. Display colors of LCD screen shall be a customizable choice among 5 color options.
23. Controller shall have a removable fascia that can be customized with replacement fascia available in 10 styles and colors.
24. Controller shall have an embedded local configuration utility using the touch screen allowing for simplified configuration, sequence selection, re-initialization, setting of setpoints and control of display settings. Controllers requiring external configuration tools or network interface for start-up and configuration are not acceptable.
25. Controller shall be configurable for display in 7 languages (EN, FR, RU, PT, ES, DE, IT).
26. Controllers shall be customizable with one of 12 different user interfaces selected based on intended use and level of local control.

27. Controller shall achieve accurate temperature control using a PI proportional-integral algorithm. Traditional differential-based controllers are not acceptable.
28. Controller shall be a BACnet MS/TP device provided with a Protocol Implementation Conformance Statement disclosing all object/SNVT properties and instance numbers to facilitate the integration process.
29. Controller shall utilize EEPROM memory to back up local configuration parameters in the event of power failure. Controllers requiring batteries, or have no provisions for retention during loss of power shall not be acceptable.
30. Controller shall have password protection to prevent unauthorized access to the configuration menu parameters.
31. Controller shall have integrated changeover function, which will allow seamless switching between cooling and heating mode based upon temperature or network value input.
32. Controller shall be provided with two (2) floating or two (2) analog proportional-integral control outputs and one configurable auxiliary output to be used for heating, or local digital output.
33. Controller shall be capable of local or remote override during unoccupied mode. The controller shall resume occupied set points and will revert back to unoccupied set points after a certain amount of time (adjustable from 0 – 24 hours in one hour increments).
34. Controller shall have an adjustable “Auto Fan” parameter depending on selected fan sequence.
35. Controller shall have configurable temporary or permanent local override set points. When the “temporary set points” mode is enabled, once the temporary occupancy timer expires, the set points will revert back to their default values.
36. Controller shall have adjustable local unoccupied heating and cooling set point limits as well as maximum heating and minimum cooling limits.
37. Controller shall have an adjustable deadband from 2 degrees F to 5 degrees F.
38. Controller shall have an adjustable proportional band from 3 degrees F to 10 degrees F.
39. Controller shall have six (6) adjustable lockout levels.
40. Controller shall be provided with six unique sequences to meet the needs of most zone temperature control applications.
41. Controller shall be pre-programmed, containing all required I/O to accomplish local HVAC temperature control.
42. Controllers shall be provided with intelligent HMI which will display services only as are available as switched through local digital input or network layer as follows:
 - a. Outdoor air temperature display only enabled when outdoor air temperature network variable is received.
 - b. “Stand-by time” and “Stand-by set point” parameters only when SCE-PIR cover described below is connected.
 - c. COM Address and various other parameters when a communication module is integrated inside the unit.
43. Controller shall have the option of a temperature scale touchscreen button instead of a Mode button to prevent occupants from overriding the schedule.
44. Controller shall have the option of having a PIR sensor. Passive infrared sensor shall be integrated into the cover of the controller. Controllers with remote motion detectors are not acceptable.
45. Acceptable Manufacturers:
 - a. Schneider Electric SE8000 Series

- 46. Printers
- 47. Printers shall be local or network printers as required. Local printers shall have a parallel or USB interface/port. Network printers shall have a 100Base-T interface with an RJ45 connection.
- 48. Alarm Printer
- 49. The printer shall be dot matrix alarm and have the ability to print graphics.
- 50. The printer shall have adjustable sprockets for paper width up to 9 1/2 inches, print at least 80 columns per line, and have a minimum print speed of 300 characters per second. Character sizing and spacing shall be selectable.
- 51. The printer shall accept sprocket-fed continuous fan-fold paper.
- 52. The printer shall have top-of-page, skip, and tab control.
- 53. The printer shall include floor stands with paper racks.
- 54. Report Printer
- 55. The report printer shall be a full color laser printer, and shall meet the following minimum requirements:
 - a. Resolution: 600 by 600 dots per inch
 - b. Printing Time: 10 pages per minute
 - c. Data Buffer Size: 128 Megabytes
 - d. Colors: The printer shall have a separate replaceable black ink cartridge or print head.
 - e. Media Type: Paper and transparency film
 - f. Media Size: Up to 11 by 17 inches
 - g. Paper Cassette: 250 sheet capacity
- 56. Ethernet Switches
- 57. Ethernet switches shall be IEEE Std 802.3 bridges which shall function as the center of a distributed-star architecture and shall be learning bridges with spanning tree algorithms per IEEE Std 802.1D. The switches shall support the connected media types and shall have a minimum of 150 percent the required ports and no fewer than 4 ports. One port shall be switch selectable as an uplink port.
- 58. Acceptable Manufacturers: Cisco or Approved Equal
- 59. Gateways
- 60. Gateways shall perform protocol translation from one non-BACnet protocol to BACnet MS/TP or BACnet/IP. Gateways shall incorporate two network connections: one shall be for connection to a BACnet MS/TP or BACnet/IP network and the second shall be as required to communicate with the non-BACnet network. Gateways shall be field programmable.
- 61. Un-interruptible Power Supply (UPS)
- 62. Provide UPS units for engineering workstation and enterprise server (if server is not part of rack mounted solution owned by IT department). The UPS units shall meet, at minimum, the following requirements:
 - a. 1400 VA or larger to handle the continuous full load use of all connected equipment for a period of five (5) minutes
 - b. Audible alarm when main power is not available to the equipment
 - c. RF noise filtering
 - d. Over voltage protection
 - e. Four outlet receptacles
 - f. Visual alert status light
 - g. Sealed maintenance free batteries
 - h. Desktop mount type unit
- 63. Acceptable Manufacturers: APC by Schneider Electric

2.03 BMS EQUIPMENT STORAGE

A. Equipment Racks

1. Equipment racks shall be either aluminum or steel with bolted or welded construction. Steel equipment racks shall be painted with a flame-retardant paint. Each equipment rack shall have guard rails and a copper grounding bar installed and grounded to the earth. Equipment racks shall be compatible with the equipment provided.
2. BMS server rack enclosure shall be supplied with stationary shelf for monitor and pull-out keyboard shelf.

B. BMS Controller Enclosures

1. BMS controller enclosures shall meet the following minimum requirements:
 - a. Enclosures located outdoors: NEMA 250 Type 3
 - b. Mechanical and Electrical Rooms: NEMA 250 Type 1
 - c. Other Locations: NEMA 250 Type 1
2. Enclosures supplied as an integral or pre-packaged part of another product are acceptable.
3. Acceptable Manufacturers: Hoffman, Rittal, Unity, or Approved Equal

2.04 AUTOMATIC CONTROL VALVES

A. General Requirements

1. Automatic control valves shall be suitable for specified controlled media. Valves shall mate and match the material of the connected piping. Control valves with electric actuators shall have required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification.
2. Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Valve bodies shall meet ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure. Unless otherwise specified or shown, valve leakage shall meet FCI 70-2 Class IV leakage rating (0.01 percent of valve Cv). Unless otherwise specified:
 - a. Bodies for 2 inch valves and smaller shall have threaded ends.
 - b. Bodies for valves 2.5 inches and larger shall have flanged-end connections.
 - c. For modulating applications, the Cv shall be within 100 to 125 percent of the Cv specified.
 - d. For two position applications (where the two positions are full open and full closed) the Cv shall be the largest available for the valve size.
 - e. Valve and actuator combination shall be fail open, fail closed, or fail last position as shown on drawings or described in the sequence of operation.
 - f. Valve assembly including actuator and limit switches, if required, shall be assembled by the valve manufacturer.

B. Characterized Control Valves

1. Valves 2" and smaller: Characterized ball valve, 400# WOG, bronze body, stainless ball and stem, pressure and temperature ports, reinforced PTFE seats & seals, screwed ends, 250 degrees F rating, close-off pressure rating of 150% of total system head pressure, and a maximum DP rating of not less than 50 psig

- a. Acceptable Manufacturers: Schneider Electric, Belimo
 - 2. Valves 2-1/2" and larger: Characterized ball valve, the valve body shall be of cast iron and rated for 150 PSI working pressure. Internal parts shall be of stainless steel, teflon or bronze.
 - a. Acceptable Manufacturers: Belimo or Approved Equal
 - 3. Two-way modulating valves used for liquids and steam shall have an equal percentage flow characteristic that yields a linear heat output.
 - 4. Three-way modulating valves shall have an equal percentage flow characteristic that yields a linear heat output.
- C. Pressure Independent Control Valves
- 1. Valves 2" and smaller: Pressure independent characterized ball valve, 400# WOG, bronze body, stainless ball and stem, pressure and temperature ports, reinforced PTFE seats & seals, screwed ends, 250 degrees F rating, 200 psig close-off pressure, and a maximum DP rating of not less than 50 psig
 - a. Acceptable Manufacturers: FlowCon, Belimo, or Approved Equal
 - 2. Valves 2-1/2" and larger: Pressure independent modulating control valves. The valve body shall be of cast iron and rated for 150 PSI working pressure. Internal parts shall be of stainless steel, teflon or bronze. Each valve shall have three pressure/temperature ports (Pete's plugs) factory installed, for inlet/outlet and within the valve pressure/temperature readings.
 - a. Acceptable Manufacturers: Flow Control Industries or Approved Equal
- D. Butterfly Valves
- 1. Two-position control butterfly valves shall be threaded lug type suitable for dead-end service to the fully-closed position, with carbon-steel bodies and non-corrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from -20 to plus 250 degrees F.
 - 2. Butterfly valves for use in modulating service shall be carbon steel body, lugged style, ANSI Class 150, adjustable PTFE packing, PTFE seat with suitable metal back-up ring, upper and lower shaft thrust bearings, 316 stainless steel one piece shaft and nylon disc with offset shaft/disc design. Normal and dead end (without downstream flanging) pressure rating shall be 275 psi.
 - 3. The rated Cv for butterfly valves shall be the value Cv at 70 percent open. Valve leakage shall meet FCI 70-2 Class VI leakage rating.
 - 4. Valve assembly including actuator and limit switches, if required, shall be assembled by the valve manufacturer.
 - 5. Acceptable Manufactures: Bray, Belimo, or Approved Equal
- E. Valves for Duct Reheat Coils and Terminal Unit Reheat Coils
- 1. Control valves with threaded ends shall be provided for duct or terminal-unit coils.
 - 2. Valves shall be characterized ball valve type or pressure independent as described above.
- F. Valves for Chilled Water, Condenser Water, and Glycol Service
- 1. Valve internal trim shall be Type 316 stainless steel.
 - 2. Valves 4 inches and larger shall be butterfly valves.

- G. Valves for High Temperature Water, Hot Water, and Dual Temperature Service
1. Valves for hot water service between 210 and 250 degrees F and dual-temperature service shall have internal trim of Type 316 stainless steel.
 2. Valves for water service below 210 degrees F shall have internal trim of brass, bronze, or Type 316 stainless steel.
 3. Nonmetallic valve parts shall be suitable for a minimum continuous operating temperature of 250 degrees F or 50 degrees F above the system design temperature, whichever is higher.
 4. Valves 8 inches and larger shall be butterfly valves.
- H. Valves for Steam Service
1. Valves for standard use 2 inches and smaller shall be unguided, unbalanced equal percentage plug type.
 2. Valves 2-1/2 inches and larger shall be guided plug type with either top and bottom guides or cage restrained plugs. Valves with pressure drops greater than 50 percent of upstream pressure shall be cage type valves with sound reduction trim.
 3. Valves 4 inches and larger shall be iron or carbon steel, flanged, 150 psig rating. Valves shall have stainless steel stems, spring-loaded Teflon or Ethylene Propylene (EP) packing, replaceable metal seats and discs. Internal valve trim shall be Type 316 stainless steel.
 4. ANSI Class IV shutoff. Valves shall conform to ANSI B16.10, ISA SP-75.
 5. Steam control valves for use with air handling unit humidifiers shall have minimum 40:1 rangeability.
- I. Valve Actuators
1. Valve actuators shall provide shutoff pressures and torques as required.
 2. Valve actuators shall be provided with declutchable hand wheels as indicated on drawings and schedules.
 3. Actuators shall be electronic. All actuators shall be fail open (FO), fail closed (FC) or fail-last-position (FL) as shown. Fail open and fail closed actuators shall be of mechanical spring return type or stored energy fail-safe return. Electric actuators shall have an electronic cut off or other means to provide burnout protection if stalled. Actuators shall have a visible position indicator. Electric actuators shall be capable of providing position feedback to the BMS controller. Actuators shall smoothly open or close the devices to which they are applied. Electric actuators shall have a full stroke response time in both directions of 90 seconds or less at rated load. Electric actuators shall be of the foot-mounted type with an oil-immersed gear train or the direct-coupled type. Electric actuators located outside shall be provided with internal heaters.
 4. Acceptable Manufacturers: Integrated with Control Valve

2.07 DAMPERS

- A. General Requirements
1. Provide automatic control dampers (ACD) as indicated on the mechanical drawings for installation by the mechanical contractor or sheet metal contractor. Refer to the mechanical drawings.
 2. Provide actuators for all automatic control dampers. Provide all required actuator mountings, installation, drive arms, shaft extensions, linkages.
 3. Provide actuators sized in accordance with manufacturers recommendations and industry standards for accurate and stable control of air flow in each application.

4. Provide damper position sensors and end switches as shown or as required.
5. Actuators shall be mounted to allow complete access for maintenance and removal. Wherever possible the BMS contractor shall mount damper actuators on the exterior of the duct/damper section. The installation of actuators within air streams will be permitted only where damper configurations and site conditions require and must be approved by the MEP consultant. In such cases, the mechanical contractor shall furnish access doors to allow access.
6. Dampers and actuators shall be configured for normal and failure positions as indicated in the sequence of operation and as indicated in the mechanical drawings.
7. Provide damper actuator installations to comply with the acoustical requirements for the project. Noise generated from dampers and actuators in air streams shall not be detectable in occupied building spaces.
8. Furnish manufacturer's installation details to the mechanical subcontractor. Provide details of all multiple section damper installations. Provide schematic diagrams for all multiple section damper installations indicating damper section dimensions, mounting configurations, linkages, actuator mounting locations, structural bracing/reinforcement, etc.
9. Automatic Fire/Smoke Dampers (FSD), Smoke Dampers (SD), fusible link fire dampers, gravity dampers and volume/balancing dampers shall be provided by the mechanical contractor or the sheet metal contractor.
10. Submit damper schedules that include, at minimum, the following for each damper:
 - a. Associated mechanical system
 - b. Damper manufacturer and model number
 - c. Actuator manufacturer and model number
 - d. Mechanical drawing reference
 - e. Damper size for each section
 - f. Parallel or opposed blade configuration
 - g. Ratio of anticipated air stream velocity to the manufacturer's maximum recommended velocity rating

B. Automatic Control Dampers (ACD)

1. Provide ACDs as shown on the mechanical drawings.
2. Modulating dampers shall be opposed blade type unless specified otherwise. Two position dampers shall be parallel or opposed blade type. Two position dampers for generator intake or discharge ventilation shall be opposed blade type.
3. The maximum leakage rate for outside air isolation AD shall not exceed 8 CFM per square foot at 4 inches W.C. The maximum leakage rate for all other AD shall not exceed 10 CFM per square foot at 4 inches W.C. Provide dampers tested and certified for leakage performance in accordance with AMCA Standard 500.
4. Frames:
 - a. 16 gauge welded galvanized steel channel, or
 - b. 3.2 mm (0.125 inch) thick formed aluminum channel
 - c. Corner bracing of frames of height or width larger than 1m. (3.28 ft.)
 - d. Channel dimensions shall be a minimum of 125 mm by 25 mm (5 inch by 1 inch)
 - e. Constructed for flanged duct work connection: Provide damper frames with flanges suitable for installation in interconnected duct work or plenums.
 - f. Sized to match the duct dimension including lining materials

C. Blades:

1. Material of construction shall be:
 - a. 21 gauge galvanized steel, with four (4) breaks, or
 - b. 22 gauge double galvanized sheets, with four (4) breaks in each sheet. Sheets shall be spot welded together, or
 - c. 14 gauge airfoil shaped double skin galvanized steel, or
 - d. 16 gauge airfoil shaped double skin extruded aluminum
2. 200 mm (8 inch) maximum width for galvanized steel
3. 150 mm (6 inch) maximum width for aluminum
4. 1.5 m (60 inch) maximum blade length
5. Replaceable edge seals made of one of the following:
 - a. Neoprene
 - b. Vinyl
 - c. Polyurethane
 - d. Silicone rubber
 - e. Synthetic elastomer
6. Side seals shall be one of the following:
 - a. Continuous spring stainless steel strip
 - b. Synthetic elastomer
 - c. Flexible aluminum compression type
7. Sections shall be installed such that blades are horizontal except where specifically noted otherwise. Vertically mounted damper blades shall have suitably rated thrust bearings.

D. Axles:

1. Materials of construction shall be:
 - a. 13 mm (0.5 inch) square zinc plated steel, or
 - b. 13 mm (0.5 inch) hexagonal zinc plated steel
2. Axles shall be fastened to the blades with bolts through the axle, rivets or welds.
3. Bearings shall be one of the following:
 - a. Oil impregnated sintered bronze, or
 - b. Stainless steel
4. Extend axle beyond the frame as necessary to match up with actuator.

E. Acceptable Manufactures: Ruskin CD-60 or Approved Equal

F. Air Flow Measuring Dampers

1. Dampers shall have integral air flow measuring sensors with honeycomb air flow straighteners.
2. Air flow sensors consist of air flow measuring blades or thermal dispersion velocity sensors mounted within the damper frame. Measurement range shall be from 250 fpm (minimum) to 5,000 fpm (maximum). Differential pressure transducers shall convert velocity measurement from the sensors to an analog input to the BMS. Damper frames shall be at minimum of 16 gauge galvanized steel or 14 gauge extruded aluminum. Blades shall be at minimum 16 gauge galvanized steel or 14 gauge aluminum. Blades shall have maximum blade width of 8 inches with steel trunnions mounted in bronze sleeve, nylon or ball bearings.
3. Furnish dampers with blade seals and stainless steel side seals. Dampers and seals shall be suitable for maximum system temperature, pressure differential and approach velocity, but not less than temperature range of -20 to 140 degrees F, pressure differential of 6 inches WG, and approach velocity of 4000 fpm.
4. Dampers, when closed, shall be guaranteed by manufacturer not to leak air in

excess of 8 CFM per sq ft at 4 inches WG differential static pressure or 3 CFM per sq ft at 1 inch WG differential static pressure.

5. Acceptable Manufacturers: Ruskin IAQ, Ebtron Air-I-Q, or Approved Equal

G. Operating Linkages

1. Operating links external to dampers, such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, shall withstand a load equal to at least 300 percent of the maximum required damper-operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crank arms shall control the open and closed positions of dampers.

H. Damper Actuators

1. Actuators shall be electronic. All actuators shall be fail open (FO), fail closed (FC) or fail-last-position (FL) as shown. Fail open and fail closed actuators shall be of mechanical spring return type or stored energy fail-safe return. Electric actuators shall have an electronic cut off or other means to provide burnout protection if stalled. Actuators shall have a visible position indicator. Electric actuators shall be capable of providing position feedback to the BMS controller. Actuators shall smoothly open or close the devices to which they are applied. Electric actuators shall have a full stroke response time in both directions of 90 seconds or less at rated load. Electric actuators shall be of the foot-mounted type with an oil-immersed gear train or the direct-coupled type. Where multiple electric actuators operate from a common signal, the actuators shall provide an output signal identical to its input signal to the additional devices. Electric actuators located outside or located in outside air stream shall be provided with internal heaters.
2. Damper actuators shall provide the torque necessary per damper manufacturer's instructions to modulate the dampers smoothly over its full range of operation.
3. Acceptable Manufacturers: Schneider Electric, Belimo

2.08 SENSORS AND INSTRUMENTATION

A. General Requirements

1. Sensors and instrumentation, including their transmitters, shall meet the specified accuracy and drift requirements at the input of the connected BMS controller's analog-to-digital conversion.
2. Sensors and instrumentation, including their transmitters, shall meet or exceed the specified range.
3. Where available, provide factory calibration certificates for all instruments and sensors. The BMS contractor shall ensure that the calibration certificate is still valid prior to owner acceptance.

B. Temperature Sensors

1. Acceptable Manufacturers: Veris Industries, Schneider Electric, ACI
2. Combination sensors (Temperature & Humidity, Temperature, Humidity, and CO2) are acceptable where appropriate as long as the basic requirements of temperature, humidity, and CO2 specifications are met.

6. Space Temperature Sensors

1. Space temperature sensors shall use precision thermistors accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.

2. Standard space sensors shall be available in an enclosure made of high impact ABS plastic for mounting on a standard electrical box.
 3. Where manual overrides are required, the sensor housing shall feature both an optional sliding mechanism for adjusting the space temperature setpoint, as well as a push button for selecting after hours operation.
 4. Where a local display is specified, the sensor shall incorporate an LCD display for viewing the space temperature, setpoint and other operator selectable parameters. Using built in buttons, operators shall be able to adjust setpoints directly from the sensor.
7. Duct Point-Type Temperature Sensors
1. Duct point-type temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of -30 to 230 degrees F.
 2. Duct point-type sensing elements shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.
 3. Sensors shall be used in application where the duct area is less than 14 square feet or where air stratification is not expected (i.e., supply air, return air).
- E. Duct Averaging Temperature Sensors
1. Duct averaging temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of -30 to 230 degrees F.
 2. The averaging sensor tube shall contain at least one thermistor for every 3 feet, with a minimum tube length of 6 feet. The averaging sensor shall be constructed of flexible copper tubing. Sensors shall be sized to ensure sensing element has a minimum length equal to 1 foot / 2 square feet of duct cross-sectional area at the installed location.
 3. Averaging sensors shall be used in applications where the duct area is larger than 14 square feet or where air stratification is expected (i.e., mixed air).
- F. Immersion Temperature Sensors
1. Immersion temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of -30 to 230 degrees F.
 2. Immersion sensing elements shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper. Immersion sensors shall be sized to ensure sensing element is located in middle third of water stream.
 3. Provide each sensor with a corresponding pipe-mounted sensor well. Sensor wells shall be stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications. Inside diameter and insertion length shall be as required for the application.
 4. Immersion sensors shall be used for measurement of temperature in all chilled and hot water applications as well as refrigerant applications.
- G. Outside Air Temperature Sensor
1. Outside air temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of -40 to 122 degrees F.
 2. Outside air sensing element shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.
 3. Probe shall be encased in PVC solar radiation shield and mounted in a noncorrosive weatherproof enclosure.
 4. The BMS contractor shall mount outside air sensors on north side of building or in area intake louvers for air handling systems to avoid thermal effects from direct

sunlight.

H. Relative Humidity Sensors/Transmitters

I. General Requirements

1. Relative humidity sensors shall use thin film capacitive type. The transmitters shall have replaceable sensing elements.
2. Transmitters shall be accurate to +/- 2 % at full scale.
3. Sensor element shall contain multi-point calibration on-board in non-volatile memory.
4. Transmitter shall accept 12-30C or 24 VAC supply power.
5. Transmitters providing analog values shall produce a linear 4-20 mA_{dc} or 0-5/0-10 V_{dc} output corresponding to the required operating range and shall have zero and span adjustment.
6. Acceptable Manufacturers: Veris Industries

J. Space Humidity Sensor/Transmitters

1. Wall mounted space RH sensors shall be provided with an integral probe and LCD display.
2. Space RH sensor operating range shall be 0-100 non-condensing, 50 to 95 degrees F.
3. Space RH sensor shall be provided in an enclosure made of high impact ABS plastic for mounting on a standard electrical box.
4. Space RH sensor shall be provided with an integrated temperature sensor where applicable
5. Space RH sensor shall be provided with a factory calibration certificate.

K. Duct Humidity Sensor/Transmitters

1. Duct mounted RH sensing element shall be encapsulated in potting material within a stainless steel probe.
2. Duct RH sensor operating range shall be 0-100 non-condensing, -40 to 122 degrees F.
3. Duct RH sensor shall be provided in an enclosure made of high impact ABS plastic for mounting on a standard electrical box.
4. Duct RH sensor shall be provided with an integrated temperature sensor where applicable
5. Duct RH sensor shall be provided with a factory calibration certificate.

L. Outside Air Humidity Sensor/Transmitters

1. Outside air RH sensing element shall be encapsulated in potting material within a stainless steel probe.
2. Outside air RH probe shall be encased in PVC solar radiation shield and mounted in a noncorrosive weatherproof enclosure. Mount outside air RH sensor on north side of building or in area intake louvers for air handling systems to avoid thermal effects from direct sunlight.
3. Outside air RH sensor operating range shall be 0-100 non-condensing, -40 to 122 degrees F.
4. Outside air RH sensor shall be provided in an enclosure made of high impact ABS plastic for mounting on a standard electrical box.
5. Outside air RH sensor shall be provided with an integrated temperature sensor where applicable

6. Outside air RH sensor shall be provided with a factory calibration certificate.
- M. Pipe Condensation Sensing Switches
1. Pipe mount condensation sensing switch shall sense either relative humidity or actual condensation at pipe point of contact. Switch shall be provided with normally closed contacts which shall energize open" when condensation is detected (relative humidity > 90 percent.
 2. Acceptable Manufacturers: Elecktronik or Approved Equal
- N. Pressure Instrumentation
1. General Requirements
 - a. Pressure sensor range shall be as shown or as required for the application. Pressure sensor ranges shall not exceed the high end range shown by more than 50 percent.
 - b. Provide remote sensing element(s) whenever operating temperature exceeds the transmitter's maximum allowable temperature.
 2. Pressure / Differential Pressure Sensors for Air Duct Applications
 - a. Sensor shall be microprocessor profiled ceramic capacitive sensing element
 - b. Transmitter shall be +/- 1% accurate in each selected range including linearity, repeatability, hysteresis, stability, and temperature compensation.
 - c. Transmitter shall be field configurable to mount on wall or duct with static probe.
 - d. Transmitter shall be field selectable for Unidirectional or Bidirectional.
 - e. Maximum operating pressure shall be 200% of design pressure.
 - f. Output shall be field selectable 4-20 mA or 0-5/0-10 VDC linear.
 - g. Transmitter shall accept 12-30 VDC or 24 VAC supply power
 - h. Transmitter shall have an LCD display
 - i. Transmitter shall have provision for zeroing by pushbutton or digital input.
 - j. Transmitter shall be provided with a factory calibration certificate.
 - k. Acceptable Manufacturers: Veris Industries
 3. Differential Pressure Sensors for Space
 - a. Sensor shall be microprocessor profiled ceramic capacitive sensing element
 - b. Transmitter shall be +/- 0.5% accurate in each selected range including linearity, repeatability, hysteresis, stability, and temperature compensation.
 - c. Transmitter shall be field configurable to mount on wall with static probe.
 - d. Transmitter shall be field selectable for Unidirectional or Bidirectional.
 - e. Output shall be field selectable 4-20 mA or 0-5/0-10 VDC linear.
 - f. Transmitter shall accept 12-30 VDC or 24 VAC supply power
 - g. Transmitter shall have an LCD display
 - h. Transmitter shall have provision for zeroing by pushbutton or digital input.
 - i. Transmitter shall be provided with a factory calibration certificate.
 - j. Acceptable Manufacturers: Veris Industries
 - k. Space differential pressure elements/pick-ups required to measure pressure shall be constructed of appropriate material for the space and application and shall be ceiling mounting or wall mounted.
 4. Liquid Differential Pressure Sensors for Water/Steam
 - a. Transmitter shall be microprocessor based

- b. Transmitter shall use two independent gauge pressure sensors to measure and calculate differential pressure.
 - c. Transmitter shall have test mode to produce full-scale output automatically.
 - d. Transmitter shall have provision for zeroing by pushbutton or digital input.
 - e. Transmitter shall have field selectable outputs of 0-5V, 0-10V, and 4-20mA.
 - f. Transmitter shall have field selectable electronic surge damping.
 - g. Transmitter shall have an electronic port swap feature.
 - h. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
 - i. Sensor shall be 17-4 PH stainless steel where it contacts the working fluid.
 - j. Accuracy shall be $\pm 1\%$ of full scale and $\pm 2\%$ of full scale for lowest selectable range
 - k. Long term stability shall be $\pm 0.25\%$
 - l. Sensor temperature operating range shall be -4 degrees F to 185 degrees F
 - m. Operating environment shall be 14 degrees F to 131 degrees F; 10-90% RH noncondensing
 - n. Proof pressure shall be 2 times maximum full scale of range
 - o. Burst pressure shall be 5 times maximum full scale of range
 - p. Transmitter shall be encased in a NEMA 4 enclosure
 - q. Enclosure shall be white powder-coated aluminum
 - r. Transmitter shall be provided with a factory calibration certificate.
 - s. Differential pressure transmitters for water and steam applications shall be provided with 3-valve manifold for servicing.
 - t. Acceptable Manufacturer: Veris Industries
5. Room Differential Pressure Monitors
- a. Room differential pressure monitor shall be connected to passive pressure probes located in each space as shown on mechanical drawings.
 - b. Room differential pressure monitor shall also be configurable to accept differential pressure analog input signal from the Building Management System.
 - c. Space differential pressure sensor range shall be plus/minus 1.0 in. WC. The accuracy shall be a minimum of plus/minus 0.25 percent of full scale. Transmitter shall provide a 4-20mA or 0-10 VDC output, or have the capability to communicate via BACnet MS/TP.
 - d. Room differential pressure monitor shall indicate pressure difference between each space with polarity indicating which space is positive or negative versus the reference space.
 - e. Room differential pressure monitor shall have local touch screen display with the ability to display a configurable message banner.
 - f. Acceptable Manufacturers: CRC, Phoenix, Setra, TSI, or Approved Equal
6. Static/Differential Pressure Switches for Air
- a. The switch shall have a user-adjustable setpoint. The setpoint shall not be in the upper or lower quarters of the range. The over pressure rating shall be a minimum of 150 percent of the highest design pressure of either input to the switch. Contacts shall open or close upon rise of pressure above the setpoint or drop of pressure below the setpoint as shown.
 - b. Switches used for high and low static applications shall have manual reset.
 - c. Acceptable Manufacturers: Cleveland Controls, Dwyer, or Approved Equal

- d. Pressure indicating differential switches for air systems (air handling unit filter monitors) shall be equal to Dwyer Series 3000 photohelic gauge.
- e. Maximum Temperature Rating: 180 degrees F
- f. Repeatability: $\pm 1\%$
- 7. Differential Pressure Switches for Water
 - a. Water differential pressure switches shall meet, at minimum, the following requirements:
 - b. 316 stainless steel body
 - c. Local display gauge
 - d. End to end accuracy not to exceed 1.0% over entire range
 - e. Easily accessible, integral non-interacting zero and span adjustment
 - f. Overpressure input protection to a minimum of five times the rated input
 - g. The differential pressure transducer shall be rated to withstand the maximum rated pressure of the system in which it is installed.
 - h. Range to be coordinated with the chiller manufacturer.
 - i. The BMS contractor will provide the isolation valves to the mechanical contractor and the mechanical contractor shall be install them.
- 8. Acceptable Manufacturers: Orange Research or Approved Equal

O. Flow Sensors

- 1. Air Flow Measurement Arrays (AFMA) – Pitot Tube Type
 - a. Air flow measuring stations shall be of the multiple averaging pitot, static pressure sensor type, with all total pressure sensors distributed for equal-area averaging of flows. They shall be of unitary (spool-piece) construction, of not less than 16-gauge sheet steel with flanged duct connections. Flow-straightening vanes shall be incorporated into the structure. Internal pitot and static sensor shall be constructed of copper to ASTM B88 standards. Instrument connections shall be 1/2" NPT Female. Mounting hardware shall not penetrate the sensor assembly. Pair with appropriate pressure transmitter as described in 2.9.5.1.
 - 1) Accuracy: $\pm 2\%$ to 6000 feet per minute ($\pm 0.5\%$ at 2000 feet per minute)
 - 2) Temperature: Maximum operating 400 degrees F
 - 3) Pressure: Maximum operating, 6-in. w.c.
 - 4) Pressure Drop: Less than 0.13 in. w.c. at 2000 feet per minute with 3/8" cell
 - 5) Flow Strengthening Vanes: 3/8"aluminum hexagon cell
 - 6) Maximum Design Flow: 6000 feet per minute
 - 7) Casing: 16-gauge galvanized sheet metal Length: 12-in. overall
 - 8) Pitot and Static Sensors: rigid copper, hard drawn, to ANSI H 23.1 and ASTM B88 standards
 - 9) Internal Fittings: copper, to ANSI B16.22 standards
 - 10) Process Connections: 1/2-in. NPT
 - b. Acceptable Manufacturers: Ultratech or Approved Equal
- 2. Fan Inlets - Air Flow Traverse Probes
 - a. Fan inlet air flow measuring probes shall be of the multiple averaging pitot, static pressure sensor type, with sensors distributed for equal-area averaging of flows. They shall be installed for a total pitot traverse of the fan inlet. Internal pitot/static sensors shall be constructed of aluminum with hard anodized finish. Instrument connections shall be 1/4" NPT Female. Pair with appropriate pressure transmitter as described in 2.9.5.1.

- 1) Accuracy: +/- 2%
 - 2) Temperature: Maximum operating 400 degrees F
 - 3) Pressure: Maximum operating, 6-in. w.c.
 - 4) Minimum Design Flow: 400 feet per minute
 - 5) Maximum Design Flow: 12,000 feet per minute
 - 6) Pitot and Static Sensors: Aluminum with hard anodized finish
 - 7) Process Connections: 1/2-in. NPT Female
- b. Acceptable Manufacturers: Ultratech or Approved Equal
3. Air Flow Measurement Arrays (AFMA) w/ Integrated Transducers – Thermal Dispersion Type
 4. Air flow sensors and transducer shall meet, at minimum, the following requirements:
 - a. Multiple independent grid measuring devices
 - b. Each measuring device shall be dual glass beaded thermistor sensing probes
 - c. Size of grid and quantity of measuring devices shall be appropriate for application to achieve the specified accuracy
 - d. Internal materials of the measuring devices and transducer suitable for continuous contact with air
 - e. Sensing support grid shall be constructed of aluminum
 - f. Microprocessor based digital transmitter
 - g. Output signal of 0-10VDC or 4-20 mA proportional to CFM
 - h. Temperature range of 0 to 120 degrees F
 - i. 3% accuracy of measured value (not full scale)
 5. Device shall be provided with a factory calibration certificate.
 6. Acceptable Manufacturers: Ebtron Gold Series or Approved Equal
- P. Fan Inlet Air Flows w/ Integrated Transducers – Thermal Dispersion Type
1. Air flow sensors and transducer shall meet, at minimum, the following requirements:
 - a. Multiple independent grid measuring devices.
 - b. Each measuring device shall be dual glass beaded thermistor sensing probes
 - c. Size of grid and quantity of measuring devices shall be appropriate for application to achieve the specified accuracy. Coordinate the exact requirements with the fan manufacturer
 - d. Internal materials of the measuring devices and transducer suitable for continuous contact with air
 - e. Sensing support grid shall be constructed of aluminum
 - f. Microprocessor based digital transmitter
 - g. Output signal of 0-10VDC or 4-20 mA proportional to CFM
 - h. Temperature range of to 120 degrees F
 - i. 3% accuracy of measured value (not full scale)
 2. Device shall be provided with a factory calibration certificate.
 3. Acceptable Manufacturers: Ebtron Gold Series or Approved Equal
- Q. Electromagnetic Flow Meters (Insertion-Type)
1. Bi-directional insertion-type electromagnetic flow meter shall be complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. The flow meter shall be hand-insertable up to 400 psi. For installations in non-metallic pipe, install grounding rings or probes. Materials

of construction for wetted metal components shall be 316 SS. The flow meter shall average velocity readings from two sets of diametrically opposed electrodes.

2. Each flow meter shall be individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to NIST. A certificate of calibration shall be provided with each flow meter.
3. Accuracy shall be within $\pm 1\%$ of rate from 2-20 ft/s. Overall turndown shall exceed 100:1.
4. Output signals shall be completely isolated and shall consist of the following: (1) analog output; 4-20mA, 0-10V, or 0-5V jumper selectable, (1) scalable dry contact output for totalization, and (1) high resolution frequency output for use with peripheral devices such as a display module or BTU meter and additional contact outputs for direction and flow totalization in each direction.
5. Device shall be provided with a factory calibration certificate.
6. Acceptable Manufacturers: Onicon or Approved Equal

R. Turbine Flow Meters (Insertion-Type)

1. Insertion-type impeller flow meter shall be complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown.
 - a. Performance:
 - 1) Accuracy $\pm 1\%$ of rate over optimum flow range; ≥ 10 upstream and ≥ 5 downstream straight pipe diameters, uninterrupted flow
 - 2) Repeatability $\pm 0.5\%$
 - 3) Velocity Range: 0.3 to 20 FPS
 - 4) Pressure Drop 0.5 psi or less @ 10 ft/sec for all pipe sizes 1.5" diameter and up
 - 5) Pressure Rating: 1000 psi @ 70 degrees F
 - b. Maximum Temperature Rating: 300 degrees F
 - c. Materials: Stainless Steel or Brass body; Stainless steel impeller
 - d. Transmitter:
 - 1) Power Supply: 12 - 30VAC or 8 - 35VDC.
 - 2) Output: 4-20 mA
 - 3) Temperature Range: 14 to 150 degrees F
 - 4) Display: 8 character 3/8" LCD (Optional)
 - 5) Enclosure: NEMA 4, Polypropylene with Viton® sealed acrylic cover
2. Device shall be provided with a factory calibration certificate.
3. Acceptable Manufacturers: Veris Industries

S. Ultrasonic Flow Meters (Clamp-On)

1. Clamp-on-type ultrasonic flow meter shall be complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown.
 - a. Liquid: water, brine, raw sewage, ethylene, glycol, glycerin, others. Contact manufacturer for other fluid compatibility
 1. Pipe Surface Temperature: Pipe diameter 1/2" to 2": -40-185 degrees F; Pipe diameter > 2": -40-250 degrees F
 2. Performance:

- a) Flow Accuracy:
 - Pipe diameter 1/2" to 3/4" 1% of full scale
 - Pipe diameter 1" to 2" 1% of reading from 4-40 FPS
 - Pipe diameter 2" to 100" 1% of reading from 1-40 FPS
- b) Flow Repeatability $\pm 0.01\%$ of reading
- c) Velocity Range: (Bidirectional flow)
 - Pipe diameter 1/2" to 2" 2 to 40 FPS
 - Pipe diameter 2" to 100" 1 to 40 FPS
- d) Flow Sensitivity 0.001 FPS
- e) Temperature Accuracy (energy): 32-212 degrees F; Absolute 0.45 degrees F; Difference 0.18 degrees F
- f) Temperature Sensitivity: 0.05 degrees F
- g) Temperature Repeatability: $\pm 0.05\%$ of reading

3. Transmitter:

- b. Power Supply: 95 to 264 VAC, 47 to 63 Hz or 10 to 28 VDC.
- c. Output: BACnet/IP or 4-20 mA
- d. Temperature Range: -40 to 185 degrees F
- e. Display: 2 line backlit LCD with keypad
- f. Enclosure: NEMA 4, (IP65), Powder-coated aluminum, polycarbonate
- g. Agency Rating: UL 1604, EN 60079-0/15, CSA C22.2, CSA Class 1 (Pipe > 2")

2. Device shall be provided with a factory calibration certificate.

3. Acceptable Manufacturers: Veris Industries

T. Thermal Dispersion Flow Switches

- 1. Thermal dispersion flow switches shall use thermal dispersion sensors to detect flow from heated reference elements whenever flow is above setpoint. Setpoint shall be adjustable between 20 and 80 percent flow. Select switches for accuracy and ranges to match sensing conditions and electrical requirements to implement intended functions. Select units for proper installation orientation.
 - a. Maximum Response Time: 1 minute
 - b. Maximum Temperature: 185 degrees F
 - c. Repeatability: ± 3 percent
- 2. Acceptable Manufacturers: Magnetrol, Dwyer, Fluid Components Inc., or

Approved Equal

a. Current Switches

3. Current switches shall provide a normally-open contact with a voltage and amperage rating greater than its connected load. Current switches shall be of split-core design. The current switch shall be rated for operation at 200 percent of the connected load. Voltage isolation shall be a minimum of 600 volts. The current switch shall be provided with adjustable switch setpoint.
4. Acceptable Manufacturer: Veris Industries

U. Current Sensors

1. Current switches shall provide a 4-20ma, 0-10V, or 0-5V signal with a voltage and amperage rating greater than its connected load. Current sensors shall be of split-core design. The current sensor shall be rated for operation at 200 percent of the connected load. Voltage isolation shall be a minimum of 600 volts. The current sensor shall be provided with adjustable setting.
2. Acceptable Manufacturer: Veris Industries

V. Floor Mounted Leak Detectors

1. Water leak detection monitors shall meet the following requirements:
 - a. Corrosion and abrasion resistant
 - b. Adjustable height
 - c. Configured for normally open or normally closed as required by the application
 - d. Form C output relay
 - e. Operating temperature range of (-20 to 120 degrees F)
2. Acceptable Manufacturer: Kele or Approved Equal

W. Low Limit Temperature Switches (Freezestats)

1. Duct mount low limit temperature switches (freezestats) shall be manual reset, low temperature safety switches with a minimum element length of 1 foot/square-foot of coverage which shall respond to the coldest 12 inch segment. The switch shall have a field-adjustable setpoint with a range of at least 15 to 55 degrees F. The switch shall have two sets of contacts, and each contact shall have a rating greater than its connected load. Contacts shall open or close upon drop of temperature below setpoint as shown and shall remain in this state until reset manually.
2. Acceptable Manufacturers: Johnson Controls

X. Damper Limit Switches

1. The damper limit switch shall be a sealed non-mercury switch with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever should be aligned with the damper blade.
2. Acceptable Manufacturers: Kele or Approved Equal

Y. Damper Position Indicators

1. The damper position indicator shall meet the following:
 - a. Direct mounting to blade of associated damper section.
 - b. 0-10 Vdc or 4-20mA output signal directly proportional to between full open and full closed position
 - c. NEMA 1 potentiometer housing for mounting inside or outside appropriate for the location

- d. Suitable mounting brackets
- 2. Acceptable Manufacturers: Kele or Approved Equal
- 3. Direct built-in feedback from the damper actuator is also acceptable in lieu of the actual separate device described above.

AA. Level Devices

- 1. Level Switches (Condensate Overflow)
 - a. Level switch shall have solid state electronic level sensing probes and SPDT contacts for indication of switch point actuation. Measurement probe shall detect rising water in cooling coil condensate drain pan. Probe shall be designed to be installed on auxiliary drain pan outlet, drain pan or inline on primary drain.
 - b. Acceptable Manufacturers: Diversitech or Approved Equal
- 2. Capacitance Type Level Transmitters
 - a. Radio Frequency (RF) type continuous level probe shall have a 4-20 mA transmitter. Output shall be linear to measured level. Probe shall have probe shielding to reject build up of conductive, sticky or viscous material. Probe length shall match vessel dimensions to measure within 6" of bottom.
 - b. Include probe brace every 4 ft if probe length exceeds 6 ft and is not installed in stilling well.
 - 1) Supply Voltage: 120 VAC/60 Hz
 - 2) Output: 2 wire, 4-20 mA DC
 - 3) Fail Safe: Low Level output on instrument failure
 - 4) Ambient Temperature Limits: -40 to 160 degrees F
 - 5) Minimum Enclosure Rating: NEMA 4
 - 6) Local Indicator: LCD meter
 - 7) Transmitter Mounting: Remote
 - 8) Performance:
 - a) Accuracy: $\pm 2\%$ nominal
 - b) Linearity: $\pm 1\%$ nominal
 - c) Repeatability: $\pm 1\%$ nominal
 - d) Response Time: 20 milliseconds
 - e) Ambient Temperature Effect: 2% per 100 degrees F maximum
 - f) Voltage Variation Effect: $\pm 0.2\%$ maximum per 10 V change
 - c. Acceptable Manufacturers: Drexelbrook, Magnetrol, Endress & Hauser, or Approved Equal
- 3. Carbon Dioxide Space Sensors
 - a. Sensor type shall be Non-dispersive infrared (NDIR).
 - b. Accuracy shall be ± 30 ppm $\pm 2\%$ of measured value with annual drift of ± 10 ppm.
 - c. Repeatability shall be ± 20 ppm $\pm 1\%$ of measured value.
 - d. Response Time shall be < 60 seconds for 90% step change.
 - e. Outputs shall be field selectable 4-20mA or 0-5/0-10VDC with SPDT Relay 1A@30VDC.
 - f. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
 - g. Output range shall be programmable to 0-2000 or 0-5000 ppm.
 - h. Transmitter shall be available in an enclosure for mounting on a standard electrical box.

- i. Transmitter shall have LCD display.
 - j. Transmitter shall have integrated temperature sensor and humidity sensor where applicable.
 - k. Temperature Range: 32 to 122 degrees F (with temperature option)
 - l. Humidity Range: 50 to 95 degrees F (with humidity option)
 - m. Acceptable Manufacturer: Veris Industries
4. Carbon Dioxide Duct Sensors
- a. Sensor type shall be Non-dispersive infrared (NDIR).
 - b. Accuracy shall be ± 30 ppm $\pm 2\%$ of measured value with annual drift of ± 10 ppm.
 - c. Repeatability shall be ± 20 ppm $\pm 1\%$ of measured value
 - d. Response Time shall be <60 seconds for 90% step change
 - e. Outputs shall be field selectable 4-20mA or 0-5/0-10VDC with SPDT Relay 1A@30VDC
 - f. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
 - g. Output range shall be programmable to 0-2000 or 0-5000 ppm.
 - h. Enclosure shall not require remote pickup tubes and make use of integrated H-beam probe to channel air flow to the sensor.
 - i. Enclosure lid shall require no screws and make use of snap on features for attachment.
 - j. Enclosure shall be made of high impact ABS plastic.
 - k. Transmitter shall have LCD display.
 - l. Temperature Range: 32 to 122 degrees F (with temperature option)
 - m. Humidity Range: 50 to 95 degrees F (with humidity option)
 - n. Acceptable Manufacturer: Veris Industries
5. Gas Monitoring Systems
- a. The system shall be a complete package with local or remote sensor(s), monitor, alarm contacts, local audible/visual alarm, local indication of current measured value for sensor, and status indicator lights for power and status of sensor. All status indicators shall be mounted on panel faceplate. Where multiple sensors are located in single space, provide single monitoring panel which incorporates display for multiple sensors. Units shall have adjustable setpoints and self-test diagnostics. Multiple gases can be measured by the same master panel.
 - 1) Gas to be detected: Carbon Monoxide (CO)
 - a) Power Requirements: 120 VAC, 50/60 Hz, 50 VA
 - b) Signal Input: Integral Sensor
 - c) Signal Output: 4-20 mA DC
 - d) Alarm Relays: 3 Amps, 120 VAC (1 Warning relay and 1 Alarm relay)
 - e) Alarm Setpoint: Two field adjustable setpoints for Warning (25 ppm) and Alarm (200 ppm)
 - f) Range: Range: 0-250 ppm CO
 - g) Sensor: Electrochemical CO Sensor
 - h) Sensor Life: 1 year minimum
 - i) Location: Shown on floor plans
 - 2) Gas to be detected: Oxygen (O2)
 - a) Power Requirements: 120 VAC, 50/60 Hz, 50 VA
 - b) Signal Input: Integral Sensor
 - c) Signal Output: 4-20 mA DC
 - d) Alarm Relays: 3 Amps, 120 VAC (1 Warning relay and 1

- Alarm relay)
 - e) Alarm Setpoint: Two field adjustable setpoints for Warning (20%) and Alarm (19.5%)
 - f) Range: Range: 0-25% O₂
 - g) Sensor: Electrochemical O₂ Sensor
 - h) Sensor Life: 1 year minimum
 - i) Location: Shown on floor plans
- b. Provide panel mounted audible alarm horn with silence switch. Provide display for indication of full scale range, sensor, zone, warning, alarm and fault status.
- c. Provide remote mounted audible/visual alarm as indicated on plans. Alarm light shall be red.
- d. The system shall have to be ability to send alarms to the BMS for warning, alarm, and system fault.
- e. Acceptable Manufacturers: Veris Industries, Toxalert, MSA, Honeywell
- 6. Refrigerant Detection System
 - a. Infrared type refrigerant detection and alarm systems detecting refrigerant in listings at adjustable detection points to provide both visual and audible alarms.
 - b. System shall conform to ANSI/BSR ASHRAE Standard 15 Safety Code for Mechanical Refrigeration including alarm light and horn outside room at each door to room and inside space as indicated on drawings.
 - c. Sensor shall be compound specific and calibrated for refrigerant used in chillers.
 - d. System shall be automatically zero at set intervals by sensing air from and uncontaminated air source. Auto zero cycle may be manually or remotely initiated.
 - e. Latched alarms shall be capable of being reset locally by remote contact closure.
 - f. System malfunction alarm shall be non-latching contact annunciated locally and remotely.
 - g. System shall require no more than annual recalibration and monthly confirmation of clean air source for auto-zero.
 - h. Provide local alarm and control panel to accept these inputs and provide outputs for system fault alarm, warning alarm and critical alarm, which shall energize emergency ventilation system. Each alarm shall have DPDT relays. Warning and critical level alarms shall energize local horn-strobe alarm. Provide contact for each alarm for monitoring by the BMS.
 - i. Refrigerant leak detection system to have the following minimum performance.
 - 1) Minimum Enclosure Rating: NEMA 4
 - 2) Power: 120 VAC/60 Hz
 - 3) Operating Temperature: 60 to 105 degrees F
 - 4) Operating Humidity: 10% to 90% RH
 - 5) Contact Ratings: 5 amp 120 VAC
 - 6) Contact(s): 2 sets DPDT independently configured for different concentrations.
 - 7) Performance:
 - a) Minimum measurable: 1 ppm as tested per UL2075
 - b) Response time: 20 seconds at 99%
 - c) Accuracy: Error < ± 2% full scale

- 8) Operating Temperature: 0 to 120 degrees F
- 9) Display: 3 digit LED or LCD displaying refrigerant gas concentration
- j. Quantity of Required Monitor Points: Two monitoring points per chiller
- k. Output: 4-20 mA/24VDC

Refrigerant Warning	Alarm Point	Critical Alarm Point
R123	15 ppm	30 ppm
R134a	200 ppm	300 ppm

- l. Acceptable Manufacturers: MSA, Honeywell, Yokogawa, or Approved Equal

BB. Emergency Stop Push Buttons

- 1. Push buttons with illuminated red mushroom heads shall be used for emergency stop switches. The push buttons shall be illuminated with the switch is engaged.
 - a. Contact Type: Two contact blocks for 2 N.O. and 2 N.C. contacts each
- 2. Unit shall be provided complete with enclosure, contact unit, and legend plate
- 3. Acceptable Manufacturers: Schneider Electric, Kele

CC. Photocells (Light Level Sensor)

- 1. Photocell level sensor shall meet, at minimum, the following requirements:
 - a. Non-corroding and weatherproof housing with sensor shield suitable for exterior installations
 - b. 4-20 mA or 0-10 VDC output proportional to the ambient light level
 - c. Accuracy at room temperature: 1%, 100 degrees F temperature: 2.5%
 - d. Solid-state photo diode circuitry and transducer as required
 - e. Sensor reading from 0 to 750 foot candles
 - f. Temperature and humidity independent
 - g. Temperature range of 10 to 120 degrees F
- 2. Acceptable Manufacturers: PLC-Multi-Point Celestial, Leviton, or Approved Equal

DD. Control Relays

- 1. Control relays shall meet, at minimum, the following requirements:
 - a. Coil ratings of 120 VAC, 50 mA or 10-30 VAC/VDC, 40 mA as suitable for the application
 - b. Complete isolation between the control circuit and the digital output
 - c. Pickup rating, time and hold rating as required for individual applications.
 - d. Rated for a minimum of ten (10) million mechanical operations and a minimum of 500,000 electrical operations
 - e. Internal status LED
- 2. Acceptable Manufacturers: Veris Industries

EE. Electric Thermostats

- 1. Electric thermostats shall be multifunction devices incorporating a temperature sensor and a temperature indicating device. Thermostats shall not contain mercury. In addition, the thermostat shall have the following as specified and shown:
 - a. External setpoint adjustment

- b. An occupancy push button override
 2. Acceptable Manufacturers: Schneider Electric
- FF. Pipe Mount Temperature Limit Switches (Aquastats)
 1. Pipe mount temperature limit switches (aquastats) shall have a field adjustable setpoint between 60 and 90 degrees F, an accuracy of plus/minus 3.6 degrees F and a 10 degrees F fixed deadband. The switch shall have two sets of contacts, and each contact shall have a rating greater than its connected load. Contacts shall open or close upon change of temperature above or below setpoint.
 2. Acceptable Manufacturers: Schneider Electric
- GG. Weather Shields
 1. Weather shields for devices or sensors located outdoors shall protect the device or sensor from moisture and sunlight.
 2. The weather shield shall be provided with adequate ventilation so that either the sensor can respond to the ambient conditions of the surroundings, or the device can work properly.
 3. Weather shields shall be constructed of galvanized steel painted white, unpainted aluminum, aluminum that is painted white, or white PVC.
- HH. Electrical Power Measurement
 1. Electrical Power Monitors, Single Point
 - a. Consist of three split-core CTs, factory calibrated as a system, hinged at both axes with the electronics embedded inside the master CT. The transducer shall measure true (rms.RMS) power demand real power (kW) consumption (kWh). Conform to ANSI C12.1 metering accuracy standards.
 - 1) Voltage Input: Load capacity as shown on drawings, 208-480 VAC, 60 Hz
 - a) Maximum Current Input: Up to 2400A
 - b) Performance:
 - Accuracy: +/- 1% system from 10% to 100% of the rated current of the CTs
 - Operating Temperature Range: 32-140 degrees F, 122 degrees F for 2400A
 - c) Output: 4 to 20 mA, Pulse, or Modbus RTU
 - d) Ratings:
 - Agency: UL508 or equivalent
 - Transducer internally isolated to 2000 VAC
 - Case isolation shall be 600 VAC.
 - b. Acceptable Manufacturers: Veris Industries
 2. Electrical Power Monitors, Single Point (High Accuracy)
 - a. Revenue grade meter. Measures voltage, amperage, real power (kW), consumption (kWh), and reactive power (kVARar), and power factor (PF) per phase and total load for a single load. Factory calibrated as a system using split core CTs. Neutral voltage connection is required.
 - 1) Voltage Input: 208-480 VAC, 60 Hz
 - 2) Current Input: Up to 2400A
 - 3) Performance:
 - i. Accuracy: +/- 1% system from 2% to 100% of the rated current of the CTs

- ii. Operating Temperature Range: 32-122 degrees F
 - b. Output: Pulse, BACnet MS/TP, Modbus RTU
 - c. Display: Backlit LCD
 - d. Enclosure: NEMA 1
 - e. Ratings:
 - 1. Agency: UL508 or equivalent
 - 2. Acceptable Manufacturers: Veris Industries
3. Electrical Power Monitors, Single Point (High Accuracy, Industrial Application)
- a. Revenue grade meter. Measures voltage, amperage, real power (kW), consumption (kWh), reactive power (kVAR), apparent power (kVA) and power factor (PF) per phase and total load for a single load. Available with data logging, Bi-directional (4-quadrant) metering, and pulse contact accumulator inputs.
 - 1) Voltage Input: 90-600 VAC, 50/60 Hz, 125-300 VDC
 - a) Current Input: 5A – 32,000A, selectable 1/3V or 1V CT inputs
 - b) Performance:
 - Accuracy shall be +/- 0.5% revenue grade
 - Operating Temperature Range: -22-158 degrees F
 - c) Output: Pulse, BACnet MS/TP, Modbus RTU
 - d) Display: Backlit LCD
 - e) Enclosure: NEMA 1, NEMA 4X shall be available as an option.
 - f) Ratings:
 - Agency: UL508 or equivalent
 - ANSI C12.20
 - b. Acceptable Manufacturers: Veris Industries
4. Electrical Power Monitors, Multiple Point (High Accuracy)
- a. Revenue grade meter. Measures volts, amps, power and energy for each circuit. 1/4 amp to 200 amp monitoring. 4 configurable alarm threshold registers.
 - 1) Voltage Input: 90-277 VAC, 60 Hz
 - 2) Current Input: 5A – 32,000A, 1/3V CT inputs
 - 3) Performance:
 - a) Accuracy: +/- 0.5% meter (split core), +/- 1% system from 1/4-100A (solid core)
 - b) Operating Temperature Range: 32-140 degrees F
 - 4) Output: Modbus RTU
 - a) Ratings:
 - Agency: UL508 or equivalent
 - ANSI C12.10
 - IEC Class I
 - b. Acceptable Manufacturers: Veris Industries

2.10 WIRE AND CABLE

A. General Requirements

1. The BMS contractor shall provide complete electrical wiring for the BMS, including 120 VAC power wiring from circuit breaker provided by Division 26 to BMS panel or device.
2. The BMS contractor shall provide control wiring, including conduit, to control devices from appropriate BMS controller enclosures.
3. The BMS contractor shall provide communications wiring, including conduit, for the BACnet MS/TP network.
4. The BMS contractor shall provide communications wiring, including conduit, for the BACnet I/P network.
5. The BMS contractor shall provide final power connections, including conduit, wire, and/or disconnect switches, to control devices and control panels from the appropriate electrical distribution panels.
6. Final connection points at devices and panels shall be made either at terminal blocks integral to the device or at separate terminal blocks mounted inside of BMS controller enclosures. Crimped connections are not allowed for termination of control wiring.
7. All wire and cable shall meet the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification.

B. Terminal Blocks

1. Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

C. Control Wiring for Analog Signals

1. Control wiring for analog signals shall be 18 AWG, copper, single or multiple-twisted, minimum 2 inch lay of twist, 100 percent shielded pairs, and shall have 300-volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.
2. Stranded twisted/shielded control conductors are required with shields to be terminated within variable frequency drive enclosures to reduce effects of noise from the VFD. The BMS contractor shall follow the VFD manufacturer's installation instructions for wiring control conductors to the VFD.

D. Control Wiring for Digital Signals

1. Control wiring for digital signals shall be 18 AWG copper and shall be rated for 300-volt service.

E. Control Wiring and Power Wiring for 120-Volt Circuits

1. Wiring for 120-volt circuits shall be 18 AWG or thicker stranded copper and shall be rated for 600-volt service.

- F. Transformers
 - 1. Transformers shall be UL 1585-3 approved. Transformers shall be sized so that the connected load is no greater than 80 percent of the transformer rated capacity.
- G. BMS Ethernet Network Copper Cable
 - 1. BMS Ethernet network cable shall meet or exceed all requirements of Category 6 cable as specified in TIA/EIA-568-B.2. Terminations, patch panels, and other hardware shall meet or exceed Category 6 specifications and shall be as specified in Telecommunications specification.
 - 2. Cabling products shall be tested and certified for use at data speeds up to at least 100 Mbps.
 - 3. Other types of media commonly used within IEEE Std 802.3 LANs (e.g., 10Base-T and 10Base-2) shall be used only in cases to interconnect with existing media. Short lengths of media and transceivers may be used in these applications. The BMS contractor shall provide separately orderable media, taps, and connectors.

2.11 TUBING

- A. General Requirements
 - 1. The BMS contractor shall provide tubing required for a complete and functional BMS, including tubing required for:
 - a. Air Flow Stations
 - b. Air Flow Sensing for VAV Boxes
 - c. Static Pressure Sensors and Switches (for air applications)
 - d. Differential Pressure Sensors and Switches (for air applications)
 - e. Differential Pressure Sensors and Switches (for water applications)
 - f. Refrigerant Detection Monitoring
 - g. Gas Detection Monitoring
 - h. Differential Pressure Sensors and Switches (for water applications)
- B. Copper
 - 1. Copper tubing shall conform to ASTM B 88 and ASTM B 88M.
- C. Stainless Steel
 - 1. Stainless steel tubing shall conform to ASTM A 269.
 - a. Plastic
 - 2. Plastic tubing shall have the burning characteristics of linear low-density polyethylene tubing, shall be self-extinguishing when tested in accordance with ASTM D 635, shall have UL 94 V-2 flammability classification or better, and shall withstand stress cracking when tested in accordance with ASTM D 1693. Plastic-tubing bundles shall be provided with Mylar barrier and flame-retardant polyethylene jacket.

PART 3- EXECUTION

3.01 CONTROL SYSTEM INSTALLATION

- A. General Installation Requirements
 - 1. Building Management System
 - a. The BMS shall be completely installed, tested in accordance with 25 08 00 (Commissioning Guideline), and ready for operation.

- b. The BMS contractor shall ensure penetrations and mounting holes in the building exterior required for the BMS installation are watertight.
 - c. The BMS contractor shall ensure that there is sufficient access for all BMS devices. All control system devices shall be located such that they can be accessed for to calibration, removal, or repair.
 - d. The BMS contractor shall ensure that the BMS installation does not interfere with the clearance requirements for mechanical and electrical system operation and maintenance.
- 2. Device Mounting
 - a. All control devices shall be installed in accordance with their manufacturer's instructions and as specified and shown.
 - b. Control devices installed in piping shall be provided with required manual valves for shutoff, equalization, purging, and calibration.
 - c. Control devices located outdoors shall have a weather shield.
- 3. BMS Controller Enclosure Mounting
 - a. The BMS contractor shall mount BMS controller enclosures on walls with suitable brackets or on a self-supporting stand. The top of the BMS enclosures shall be no higher than 6 ft above the finished floor.
 - b. The BMS contractor shall mount controller enclosures so that panel door can swing fully open without obstruction.
- 4. BMS Controller Enclosure Layout
 - a. Terminal strips shall be located either horizontally in upper half of the back panel or vertically.
 - b. 24 VDC and 120 VAC, wire, cable, and devices shall be separated by 6 inches minimum.
 - c. Wire and cable shall be enclosed in wireways or bundled w/ wire ties and secured to the back panel. This does not apply to wire exiting wireways, to terminal strips, or to panel mounted devices.
 - d. Controllers shall be spaced according to manufacturer's requirements with at least 2 inches minimum between controllers and other devices on panel and 1 inch between controller front and door mounted devices. Ensure adequate space is allowed for device heat dissipation and for future expansion modules.
 - e. Controller or control devices shall not be mounted on the sides of the enclosure.
 - f. Controller enclosures shall not be used as a wire pass-through to an adjacent panel.
 - g. Labels inside enclosures shall be attached using adhesive and shall not be hand written.
- 5. Labels and Tags
 - a. Labels and tags shall match to the naming convention shown on the as-built drawings.
 - b. Laminated plastic nameplates shall be provided for all BMS controller and transformer enclosures. Laminated plastic shall be 0.125 inch thick, white with black center core. Nameplates shall be a minimum of 1 by 3 inch with minimum 0.25 inch high engraved block lettering. Enclosures shall be named as shown on drawings or as follows:
 - 1) BMS Controller Enclosures: BMS-X where X represents the controlled system
 - 2) BMS Transformer Enclosures: BMS-PWR-X, where X represents the equipment being powered

- c. All BMS hardware located in enclosures shall be properly labeled.
- d. All BMS sensors and actuators shall be tagged.
- e. Tags shall be plastic or metal and shall be attached directly to each device (i.e., sensors) or attached by a metal chain (i.e., valves), when not in finished spaces. In finished spaces, tags can be put inside the cover of the device.

B. BMS Hardware

- 1. All BMS controllers shall be installed in enclosure except for BMS controllers used to control terminal units.
- 2. The BMS contractor shall provide a unique BMS controller for each major piece of equipment. Exhaust fans and miscellaneous monitoring may reside on controllers designated for other major equipment.
- 3. Control software algorithm and inputs and outputs for a single system or piece of equipment shall reside on a single controller. Control loops shall not rely on the network for control.
- 4. Where multiple controllers reside in a single control panel, provide a separate disconnect (or fuse) for each controller.
- 5. The quantity of controllers connected on one secondary MS/TP network shall not exceed 75 percent of maximum node capacity published by the BMS manufacturer. If necessary, provide additional hardware, over and above that shown on MEP consultant's drawings, to meet this requirement.

C. I/O Point Capacity

- 1. BMS contractor shall provide I/O point capacity required for system control plus expandable capability for I/O points in each control panel. Addition I/O shall not be required for terminal unit controllers.
- 2. Expandable I/O point capacity shall be defined as the ability to add terminal connections, which are ready to accept digital or analog inputs, dry contacts for digital outputs, and variable voltage or current terminals for analog outputs. Universal type points are acceptable for both discrete and analog type points.
- 3. Minimum add of I/O points in each control panel shall be as follows:
 - a. (1) Digital Input
 - b. (1) Digital Output
 - c. (1) Analog Input
 - d. (1) Analog Output

D. BMS Software

- 1. Software Installation
 - a. BMS contractor shall install software as follows:
 - 1) Operating system: The BMS contractor shall install the operating system on the servers and workstations and configure the required user names and passwords.
 - 2) Virus Protection software: The BMS contractor shall install the virus protection software on each server and workstation and shall configure a weekly virus scan.
 - 3) BMS software: The BMS contractor shall install and configure Building Management System software for the following servers and workstations:
 - a) Enterprise Server
 - b) Reports Server

- c) Engineering Workstation
 - 4) BMS End User Web-Access: The BMS contractor shall confirm working web-access to the BMS for (5) end user provided computers.
2. BMS Software Programming and Graphics
- a. All communication between the BMS Enterprise Server, BMS Reports Server, BMS Engineering Workstation, and Automation Servers shall be via BACnet/IP and in accordance with ASHRAE 135.
 - b. For equipment requiring IP addresses, the BMS contractor shall coordinate with the end user to obtain IP addresses.
 - c. The BMS contractor shall establish network object bindings as necessary to support software functionality:
 - 1) BACnet objects used for display on currently active displays shall be updated (via COV) as necessary to meet display requirements.
 - 2) BACnet objects used for currently active trends shall be updated (via COV) as necessary to meet trend interval requirements.
 - 3) BACnet alarm objects shall be bound from the device originating the alarm to the software. Alarms shall use the acknowledged service.
 - d. The BMS contractor shall create color graphic display screens as follows:
 - 1) Color graphic display screen of building or site (main or home page). Include “hot link” navigation buttons on the graphics that allow the end user to get to specific floor or equipment displays, and critical monitoring displays.
 - 2) At least one color graphic display screen per floor. The status of environmental condition on the floor as well as smoke conditions and lighting conditions shall be displayed on the graphic. Include “hot link” navigation buttons on the graphics and outlined equipment blocks that allow the end user to get to a default home page as well as systems that are on the floor.
 - 3) One color graphic display screen for each system controlled or monitored by the BMS. The status of each input and output shall be displayed on the graphic. Include “hot link” navigation buttons on the graphics that allow the end user to get to the home page graphic, a floor level graphics, parent and child equipment, and critical monitoring displays.
 - 4) At least one color graphic display screen that depicts critical alarm conditions. Include “hot link” navigation buttons on the graphics that allow the end user to get to a default home page as well as floor level views and critical systems from which the alarms originated.
 - e. The BMS contractor shall configure user accounts which include usernames, passwords, and permission levels for all authorized users. After final acceptance of system, the BMS contractor shall work with the end user to remove all temporary user names and passwords that were required for commissioning purposes.
 - f. The BMS contractor shall configure alarm handling as detailed in the sequence of operation. The BMS contractor shall coordinate alarm strategy with the end user.
 - g. The BMS contractor shall configure the scheduling function of the BMS software to schedule systems as shown in the sequence of operation and

- as specified.
- h. The BMS contractor shall create trends and reports for required points as shown in the sequence of operation and as specified.
3. BACnet Naming and Address Convention
- a. The BMS contractor shall coordinate with the end user and provide unique naming and addressing for BACnet networks and devices as follows:
- 1) MAC Addresses
 - a) Every BACnet device shall have an assigned and documented MAC Address unique to its network.
 - b) For Ethernet networks, the BMS contractor shall document the MAC Address assigned at its creation.
 - c) For MS/TP networks, the BMS contractor shall assign from the MAC Address from a range as indicated by manufacturer's documentation.
 - 2) Network Numbering
 - a) The BMS contractor shall assign unique numbers to each new network installed on the BACnet network.
 - 3) UDP Port Number
 - a) The BMS contractor shall set every BACnet Building Controller (B-BC) and BACnet Router UDP port number to 47808 (BAC0) or a different UDP legal port number if needed.
 - 4) Device Object Identifier Property Number
 - a) The BMS contractor shall assign unique Device "Object_Identifier" property numbers or device instances for each device on the BACnet network.
 - 5) Object Name Property Text (Other than Device Objects)
 - a) The Object Name property field shall support 32 minimum printable characters.
 - b) The BMS contractor will provide object naming convention consistent with BMS vendor standards.
 - 6) Object Identifier Property Number (Other than Device Objects)
 - a) The BMS contractor shall assign Object Identifier property numbers as shown or at the BMS contractor's discretion.
4. Minimum BACnet Object Requirements
- a. Use of Standard BACnet Objects
- 1) For the following points and parameters, the BMS contractor shall use standard BACnet objects:
 - a) All hardwired I/O
 - b) setpoints
 - c) calculated values
 - d) equipment status
 - e) PID loop parameters
 - f) alarms
 - g) trends
 - h) schedules
- b. BACnet Object Description Property
- 1) The Object Description property shall support 32 minimum printable characters.
 - 2) For each BACnet object, the BMS contractor shall complete the

description property field using a brief, narrative, plain English description specific to the object and project application (i.e., "AHU On").

c. Analog Input, Output, and Value Objects

- 1) The BMS contractor shall create Description and/or Device Type text strings that match the signal type and engineering units shown on the drawings.

d. Binary Input, Output, and Value Objects

- 1) The BMS contractor shall create Inactive Text and Active Text property descriptions that match the conditions shown on the drawings.

e. Calendar Object

- 1) For devices with scheduling capability, the BMS contractor shall create at least one Calendar Object with ten-entry capacity and enable the writeable Date List property and support all calendar entry data types.

f. Schedule Object

- 1) The BMS contractor shall use Schedule Objects for all building system scheduling.

g. Loop Object or Equal

- 1) The BMS contractor shall use Loop Objects or equivalent BACnet objects in each applicable field device for PID control.

h. Trend Object

- 1) The BMS contractor shall use Trend Objects for all building system trending.

5. Minimum BACnet Service Requirements

a. Command Priorities

- 1) The BMS contractor shall use commandable BACnet objects to control machinery and systems, providing the priority levels listed below:

<u>Priority Level</u>	<u>Application</u>
1	Manual-Life Safety
2	Automatic-Life Safety
3	(User Defined)
4	(User Defined)
5	Critical Equipment Control
6	Minimum On/Off
7	(User Defined)
8	Manual Operator
9	(User Defined)

- 10 (User Defined)
- 11 Load Shedding
- 12 (User Defined)
- 13 (User Defined)
- 14 (User Defined)
- 15 (User Defined)
- 16 (User Defined)

b. Alarming

1) Alarm Priorities

- a) The BMS contractor shall coordinate alarm and event notification with the end user.

2) Notification Class

- a) The BMS contractor shall enable writeable Priority, Ack Required, and Recipient List properties of Notification Class objects.

3) Event Notification Message Texts

- a) The BMS contractor shall use condition specific narrative text and numerical references for alarm and event notification.

c. Updating Displayed Property Values

- 1) The BMS contractor shall create the graphic display screens to receive property values based on receipt of confirmed and unconfirmed Change of Value notifications. The COV increment shall be adjustable using BACnet services.

E. Gateways

- 1. Gateways may be used for communication with non-BACnet control hardware.

F. Dampers

1. Damper Installation

- a. The BMS contractor shall work with the mechanical contractor to ensure that the air flow stations are installed in accordance with the manufacturer's installation instructions.
- b. Dampers shall move freely without undue stress due to twisting or other installation error.
- c. Damper blades shall open completely and close completely.

2. Damper Actuators

- a. Damper actuators shall not be mounted in the air stream.
- b. Actuators shall be installed so that their action seals the damper and moves the blades smoothly.
- c. Multiple actuators shall not be connected to a common drive shaft.

3. Room Instrument Mounting

- a. Room instruments, including but not limited to wall mounted thermostats and sensors located in occupied shall be mounted 54 inches above the floor unless otherwise specified.
 - 1) Temperature and humidity sensors for vivarium spaces, critical

- laboratory areas, or GMP spaces shall be mounted in the exhaust air duct.
- 2) All other thermostats, temperature, humidity, and CO2 room sensors for non-GMP areas shall be wall mounted.
4. Duct Averaging Temperature Sensors
- Sensors mounted in air streams where stratification exists shall be averaging type as specified.
 - The BMS contractor shall mount the averaging sensor across the duct area in a "Z" pattern using appropriate mounting clips.
5. Duct Humidity Sensors
- If possible, the BMS contractor shall install duct humidity sensors in supply air ducts at least 10 feet downstream of the humidifier.
6. Flow Meters
- The BMS contractor shall work with the mechanical contractor to ensure that the flow meters are installed in accordance with the manufacturer's installation instructions.
7. Air Flow Stations
- The BMS contractor shall work with the mechanical contractor to ensure that the air flow stations are installed in accordance with the manufacturer's installation instructions.
8. Low Limit Temperature Switches (Freezestat)
- Freezestats shall be provided on AHUs with cooling coils to sense the temperature at the location shown.
 - A sufficient number of freezestats shall be installed to provide complete coverage of the duct section.
 - Built-in manual reset switches shall be accessible locations so they can be easily be reset.
 - The BMS contractor shall install the freezestat sensing element in a serpentine pattern and in accordance with the manufacturer's installation instructions.
9. Duct Smoke Detectors
- Duct smoke detectors shall be provided by the fire alarm contractor and located in supply and return air ducts in accordance with the fire alarm system specification.
 - The BMS contractor shall connect the BMS to the auxiliary contacts of the air handling unit's duct smoke detectors or dedicated ZAMs as required for system safeties and to provide alarms to the BMS.
10. Wire and Cable
- Wire and Cable shall be installed without splices between control devices and in accordance with NFPA 70 and NFPA 90A.
 - Penetrations required in fire-rated construction shall be firestopped in accordance with the firestopping specifications.
 - Instrumentation grounding shall be installed per the device manufacturer's instructions and as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system.
 - Cables and wires shall be tagged at both ends, with tagging matching the tags on the BMS control drawings.
 - Electrical work shall be as specified in specification section 26. Wiring external to enclosures shall be run as follows:
 - 1) Wiring other than low-voltage control and low-voltage network wiring shall be installed in conduit.

- 2) Low-voltage control and low-voltage network wiring not in accessible suspended ceilings shall be installed in conduit.
 - 3) Low-voltage control and low-voltage network wiring in accessible suspended ceilings over occupied spaces can be installed in conduit or can be plenum rated cable as detailed:
 - a) Plenum rated cable in accessible suspended ceilings over occupied spaces may be run without conduit or raceways.
 - b) Plenum rated cable shall be routed along building structure lines using Bridal Rings, J-hooks or other mounting methods as approved by the MEP consultant.
 - c) Use of wire-ties for attaching cabling to duct brackets, piping, ceiling grid supports or structure is not acceptable. Diagonal routing is also not allowed.
11. Sensing Tubing / Pneumatic Lines
- a. General
 - 1) Sensing tubing / pneumatic lines installed outside shall be hard copper.
 - 2) Sensing tubing / pneumatic lines shall be concealed except in mechanical rooms and other areas where other tubing and piping is exposed.
 - 3) Sensing tubing / pneumatic lines in mechanical/electrical rooms shall be routed so that the lines are easily traceable.
 - 4) All sensing tubing /pneumatic lines and sensing tubing / pneumatic line bundles, exposed to view shall be installed neatly in lines parallel to the lines of the building.
 - 5) Sensing tubing / pneumatic lines shall be purged prior to final connection to control devices.
 - 6) Sensing tubing / pneumatic lines shall be tagged at both ends, with tagging matching the tags on the BMS control drawings.
 - b. Copper Tubing
 - 1) Copper tubing shall be hard-drawn in exposed areas and either hard-drawn or annealed in concealed areas.
 - 2) Only tool-made bends shall be used.
 - 3) Fittings for copper tubing shall be brass or copper solder joint type except at connections to apparatus, where fittings shall be brass compression type.
 - c. Plastic Tubing
 - 1) Plastic tubing shall be run within covered raceways or conduit except when otherwise specified.
 - 2) Plastic tubing shall not be used for applications where the tubing could be subjected to a temperature exceeding 130 degrees F.
 - 3) Fittings for plastic tubing shall be for instrument service and shall be brass or acetal resin of the compression or barbed push-on type.
 - 4) Except in walls and exposed locations, plastic multi-tube instrument tubing bundle without conduit or raceway protection may be used where a number of air lines run to the same points. The multi-tube bundle must be enclosed in a protective sheath, run parallel to the building lines, and adequately supported.
 - d. Sensing Tubing for Space Pressure
 - 1) Sensing tubing for space pressure applications shall be plastic or copper tubing. Horizontal and vertical runs of plastic tubing or soft

copper tubing shall be installed in raceways or rigid conduit dedicated to tubing. Dedicated raceways, conduit, and hard copper tubing not installed in raceways shall be supported every 6 feet for horizontal runs and every 8 feet for vertical runs.

- e. Sensing Tubing for Liquid and Steam
 - 1) Sensing tubing for connection of sensing elements and transmitters to liquid and steam lines shall be copper with brass compression fittings.
- f. Sensing Tubing for Duct Pressure or Flow
 - 1) Connections to sensing elements in ductwork shall be plastic tubing.
- g. Existing Controls Coordination
 - 1) The BMS contractor shall ensure that existing controls which are to be reused are tested and calibrated for proper operation. Existing controls which are found to be defective shall be noted to the end user and CM. The BMS contractor shall not be responsible for any material or labor costs associated with the repair of existing controls.
 - 2) Switchover from the existing control system to the new BMS must be coordinated with the end user.
 - 3) Demolition of the existing controls no longer required shall occur after the new BMS is in place and functioning properly.

3.02 DRAWINGS

- A. BMS Contractor Design Drawings
 - 1. The BMS contractor shall prepare and submit shop drawings as previously detailed in section 1.7.4.
- B. Final As-Built Drawings
 - 1. The BMS contractor shall update the shop drawings to reflect final as-built data and submit as specified.
 - 2. Floor level drawings to include duct, pipe and wall mounted end devices per installation.

3.03 BMS CALIBRATION & START-UP & TESTING

- A. As detailed in 25 08 00, the BMS contractor shall adjust, calibrate, measure, program, configure, set the time schedules, set alarms, and otherwise perform all necessary actions to ensure that the systems are installed correctly and function as specified and shown in the sequence of operation.

3.04 BMS DEMONSTRATION, ACCEPTANCE PERIOD, ST AND IST

- A. Refer to 25 08 00

3.05 TRAINING

- A. General Requirements
 - 1. Training courses shall be conducted as described below in the maintenance, service

and operation of the system, including specified hardware and software. The training shall be oriented to the specific system(s) provided for this project. The BMS contractor is responsible for providing audiovisual equipment any required training material and supplies. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday.

2. Refer to specification section 25 08 00 for requirements related to training and demonstration associated with the commissioning process.

B. Training Course Documentation

1. The BMS contractor shall prepare training documentation to consist of:
 - a. Course Attendee List
 - b. Training Manuals: Training manuals shall include an agenda, detailed objectives for the course, and a detailed description of the subject matter for part of the course. If the BMS contractor chooses to present portions of the course by audiovisuals, copies of those audiovisuals shall be delivered to the end user as a part of the printed training manuals. Training manuals shall be delivered for each trainee with two additional manuals turned over to the project site.

C. Operator Training

1. The Operator Training course shall be taught at the project site on the installed system for a period of no less than 2 training days during commissioning phase if possible. A maximum of 10 personnel will attend this course. This training shall be targeted towards training end users in the day-to-day operation and basic maintenance of the BMS. Upon completion of this course, each student, using appropriate documentation, should be able to start the BMS, operate the BMS, recover the BMS after a failure, perform routine maintenance, and describe the specific hardware architecture and operation of the BMS. Typical HVAC systems should be treated as a group, with instruction on the physical layout of one such system. This course shall at a minimum include:
 - a. General system architecture
 - b. Functional operation of the system
 - c. System start-up procedures
 - d. Graphics navigation
 - e. Schedule configuration
 - f. Trend configuration
 - g. Reports generation
 - h. Alarm reporting and acknowledgements
 - i. Perform point overrides and override release
 - j. Retrieval of historical trends and logs
 - k. Web-access to BMS
 - l. functionality
 - m. Software diagnostics
 - n. Maintenance procedures:
 - 1) Locations and layout of typical BMS controller enclosure
 - 2) Locations and layout of sampling of terminal equipment
 - 3) Location of typical control end devices
 - 4) Calibration, adjustment, commissioning, tuning, repair procedures
 - 5) Calibration frequency

- 6) Troubleshooting and diagnostic procedures for end devices
- 7) Troubleshooting and diagnostic procedures for controllers
- 8) Preventive maintenance procedures and schedules
- o. Disaster recovery procedures

END OF SECTION

SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes pipe and fitting materials and joining methods for the following:

1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Plastic pipe and fittings.
4. Fiberglass pipe and fittings.
5. Joining materials.
6. Transition fittings.
7. Dielectric fittings.
8. Bypass chemical feeder.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:

1. Pipe.
2. Fittings.
3. Joining materials.
4. Bypass chemical feeder.

- B. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for adhesives.>
2. <Double click to insert sustainable design text for EPDs and HPDs.>

- C. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.

4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 1. Suspended ceiling components.
 2. Other building services.
 3. Structural members.
- B. Qualification Data: For Installer.
- C. Welding certificates.
- D. Field quality-control reports.
- E. Preconstruction Test Reports:
 1. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
 1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
 2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.
- B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.6 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: **[Owner will engage]** **[Engage]** a qualified testing agency to perform preconstruction testing on water quality.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
1. Hot-Water Heating Piping: [100 psig] <Insert psig> at [200 deg F] [180 deg F] <Insert temperature>.
 2. Chilled-Water Piping: [150 psig] <Insert psig> at [73 deg F] <Insert temperature>.
 3. Dual-Temperature Heating and Cooling Water Piping: [100 psig] <Insert psig> at [180 deg F] <Insert temperature>.
 4. Condenser-Water Piping: [150 psig] <Insert psig> at [73 deg F] <Insert temperature>.
 5. Glycol Cooling-Water Piping: [150 psig] <Insert psig> at [150 deg F] <Insert temperature>.
 6. Makeup-Water Piping: [80 psig] [150 psig] <Insert value> at [73 deg F] [150 deg F] <Insert temperature>.
 7. Condensate-Drain Piping: [150 deg F] [180 deg F] <Insert temperature>.
 8. Blowdown-Drain Piping: [180 deg F] [200 deg F] <Insert temperature>.
 9. Air-Vent Piping: [180 deg F] [200 deg F] <Insert temperature>.
 10. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: [ASTM B 88, Type L] [ASTM B 88, Type M].
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
 3. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, [prelubricated] EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.
- E. Copper or Bronze Pressure-Seal Fittings:
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Housing: Copper.
 3. O-Rings and Pipe Stops: EPDM.
 4. Tools: Manufacturer's special tools.
 5. Minimum 200-psig working-pressure rating at 250 deg F.
- F. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

G. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 1. Material Group: 1.1.
 2. End Connections: Butt welding.
 3. Facings: Raised face.
- H. Grooved Mechanical-Joint Fittings and Couplings:
 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 3. Couplings: Ductile- or malleable-iron housing and **[EPDM]** **[or]** **[nitrile]** gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- I. Plain-End Mechanical-Joint Couplings:
 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Housing: ASTM A-536 Grade 65-45-12 segmented ductile iron or type 304 stainless steel.
 3. Housing coating: **[None]** **<Insert coating type>**.
 4. Gasket: **[EPDM]** **[NBR]**.
 5. Sealing Mechanism: Double-lip sealing system or carbon steel case-hardened jaws.

6. Bolts, hex nuts, washers, or lock bars based on manufacturer's design.
7. Minimum Pressure Rating: Equal to that of the joined pipes.

J. Steel Pressure-Seal Fittings:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Housing: Steel.
3. O-Rings and Pipe Stop: EPDM.
4. Tools: Manufacturer's special tool.
5. Minimum 300-psig working-pressure rating at 230 deg F.

K. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 PLASTIC PIPE AND FITTINGS

A. CPVC Plastic Pipe: ASTM F 441/F 441M, with wall thickness as indicated in "Piping Applications" Article.

1. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.

B. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.

1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.5 FIBERGLASS PIPE AND FITTINGS

A. RTRP: ASTM D 2996, filament-wound pipe with tapered bell and spigot ends for adhesive joints.

B. RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.

C. Flanges: ASTM D 4024. Full-face gaskets suitable for the service, minimum 1/8-inch thick, 60-70 durometer. ASTM A 307, Grade B, hex head bolts with washers.

2.6 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Solvent Cements for CPVC Piping: ASTM F 493.
 - 1. [<Double click to insert sustainable design text for solvent cement.>](#)
 - 2. [<Double click to insert sustainable design text for low emitting adhesives.>](#)
- H. Solvent Cements for PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - 1. [<Double click to insert sustainable design text for solvent cement.>](#)
 - 2. [<Double click to insert sustainable design text for adhesive primer.>](#)
 - 3. [<Double click to insert sustainable design text for low emitting adhesives.>](#)
 - 4. [<Double click to insert sustainable design text for adhesive primer.>](#)
- I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.
 - 1. [<Double click to insert sustainable design text for fiberglass pipe adhesive.>](#)
 - 2. [<Double click to insert sustainable design text for low emitting adhesives.>](#)

2.7 TRANSITION FITTINGS

- A. Plastic-to-Metal Transition Fittings:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.
- B. Plastic-to-Metal Transition Unions:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.8 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: [**125 psig minimum at 180 deg F**] [**150 psig**] [**250 psig**] **<Insert value>**.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: [**125 psig minimum at 180 deg F**] [**150 psig**] [**175 psig**] [**300 psig**] **<Insert value>**.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: [**150 psig**] **<Insert value>**.
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. Standard: IAPMO PS 66.
 - b. Electroplated steel nipple, complying with ASTM F 1545.
 - c. Pressure Rating: [**300 psig at 225 deg F**] **<Insert value and temperature>**.
 - d. End Connections: Male threaded or grooved.
 - e. Lining: Inert and noncorrosive, propylene.

2.9 BYPASS CHEMICAL FEEDER

- A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-water heating piping, aboveground, [NPS 2 and smaller] <Insert pipe size range>, shall be[**any of**] the following:
 1. [Type L] [Type M], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [pressure-seal] joints.
 2. [Schedule 40] [Schedule 30] [Schedule 20], Grade B steel pipe; [Class 125, cast-iron] [Class 150, malleable-iron] [Class 250, cast-iron] [Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 4. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
- B. Hot-water heating piping, aboveground, [NPS 2-1/2 and larger] <Insert pipe size range>, shall be[**any of**] the following:
 1. [Type L] [Type M], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.
 2. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 3. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 4. [Schedule 40] <Insert schedule number> steel pipe, plain-end mechanical-coupled joints.
 5. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 6. RTRP and RTRF with adhesive or flanged joints.
- C. Hot-water heating piping installed belowground and within slabs shall be[**either of**] the following:
 1. Type K, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints. Use the fewest possible joints.
 2. RTRP and RTRF with adhesive or flanged joints.
- D. Chilled-water piping, aboveground, [NPS 2 and smaller] <Insert pipe size range>, shall be[**any of**] the following:
 1. [Type L] [Type M], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [pressure-seal] joints.
 2. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; [Class 125, cast-iron] [Class 150, malleable-iron] [Class 250, cast-iron] [Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 4. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.

- E. Chilled-water piping, aboveground, [NPS 2-1/2 and larger] <Insert pipe size range>, shall be[**any of**] the following:
1. [Type L] [Type M], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.
 2. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 3. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 4. [Schedule 40] <Insert schedule number> steel pipe, plain-end mechanical-coupled joints.
 5. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 6. RTRP and RTRF with adhesive or flanged joints.
- F. Chilled-water piping installed belowground and within slabs shall be[**either of**] the following:
1. Type K, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints. Use the fewest possible joints.
 2. RTRP and RTRF with adhesive or flanged joints.
- G. Dual-temperature heating and cooling water piping, aboveground, [NPS 2 and smaller] <Insert pipe size range>, shall be[**any of**] the following:
1. [Type L] [Type M], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [pressure-seal] joints.
 2. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; [Class 125, cast-iron] [Class 150, malleable-iron] [Class 250, cast-iron] [Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 4. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
- H. Dual-temperature heating and cooling water piping, aboveground, [NPS 2-1/2 and larger] <Insert pipe size range>, shall be[**any of**] the following:
1. [Type L] [Type M], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.
 2. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 3. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 4. [Schedule 40] <Insert schedule number> steel pipe, plain-end mechanical-coupled joints.
 5. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 6. RTRP and RTRF with adhesive or flanged joints.
- I. Dual-temperature heating and cooling water piping installed belowground and within slabs shall be[**either of**] the following:
1. Type K, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints. Use the fewest possible joints.
 2. RTRP and RTRF with adhesive or flanged joints.

- J. Condenser-water piping, aboveground, [NPS 2 and smaller] <Insert pipe size range>, shall be[**any of**] the following:
1. [Type L] [Type M], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [pressure-seal] joints.
 2. [Schedule 80] [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; [Class 125, cast-iron] [Class 150, malleable-iron] [Class 250, cast-iron] [Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 4. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
- K. Condenser-water piping, aboveground, [NPS 2-1/2 and larger] <Insert pipe size range>, shall be[**any of**] the following:
1. [Type L] [Type M], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.
 2. [Schedule 80] [Schedule 40] [Schedule 30] [Schedule 20] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 3. [Schedule 80] [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 4. [Schedule 40] <Insert schedule number> steel pipe, plain-end mechanical-coupled joints.
 5. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 6. RTRP and RTRF with adhesive or flanged joints.
- L. Condenser-water piping installed belowground and within slabs shall be[**either of**] the following:
1. Type K, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints. Use the fewest possible joints.
 2. RTRP and RTRF with adhesive or flanged joints.
- M. Glycol cooling-water piping, aboveground, [NPS 2 and smaller] <Insert pipe size range>, shall be[**any of**] the following:
1. [Type L] [Type M], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [pressure-seal] joints.
 2. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; [Class 125, cast-iron] [Class 150, malleable-iron] [Class 250, cast-iron] [Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 4. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
- N. Glycol cooling-water piping, aboveground, [NPS 2-1/2 and larger] <Insert pipe size range>, shall be[**any of**] the following:
1. [Type L] [Type M], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.
 2. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

3. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 4. [Schedule 40] <Insert schedule number> steel pipe, plain-end mechanical-coupled joints.
 5. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 6. RTRP and RTRF with adhesive or flanged joints.
- O. Glycol cooling-water piping installed belowground and within slabs shall be[**either of**] the following:
1. Type K, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints. Use the fewest possible joints.
 2. RTRP and RTRF with adhesive or flanged joints.
- P. Makeup-water piping installed aboveground shall be[**either of**] the following:
1. [Type L] [Type M], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.
 2. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings, and solvent-welded joints.
- Q. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.
- R. Condensate-Drain Piping: [Type M] [Type DWV], drawn-temper copper tubing, wrought-copper fittings, and soldered joints[**or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints**].
- S. Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.
- T. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
- U. Air-Vent Piping:
1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
 2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.
- V. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using [**mechanically formed**] tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to the following:
 - 1. Section 23 05 23.11 "Globe Valves for HVAC Piping."
 - 2. Section 23 05 23.12 "Ball Valves for HVAC Piping."
 - 3. Section 23 05 23.13 "Butterfly Valves for HVAC Piping."
 - 4. Section 23 05 23.14 "Check Valves for HVAC Piping."
 - 5. Section 23 05 23.15 "Gate Valves for HVAC Piping."
- Q. Install unions in piping, [**NPS 2**] <**Insert pipe size**> and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- R. Install flanges in piping, [**NPS 2-1/2**] <**Insert pipe size**> and larger, at final connections of equipment and elsewhere as indicated.
- S. Install shutoff valve immediately upstream of each dielectric fitting.

- T. Comply with requirements in Section 23 05 16 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
- U. Comply with requirements in Section 23 05 53 "Identification for HVAC Piping and Equipment" for identifying piping.
- V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."
- W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."
- X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for [NPS 2] <Insert pipe size> and Smaller: Use dielectric [**nipples**] [**unions**].
- C. Dielectric Fittings for [NPS 2-1/2 to NPS 4] <Insert pipe size range>: Use dielectric [**flanges**] [**flange kits**] [**nipples**].
- D. Dielectric Fittings for [NPS 5] <Insert pipe size> and Larger: Use dielectric flange kits.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- C. Install the following pipe attachments:
 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 4. Spring hangers to support vertical runs.
 5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

- D. Install hangers for [**copper tubing**] [**and**] [**steel piping**], with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- F. Install hangers for fiberglass piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- G. Support horizontal piping within [**12 inches**] <Insert dimension> of each fitting and coupling.
- H. Support vertical runs of [**copper tubing**] [**and**] [**steel piping**] to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- I. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.5 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

- H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
 - 4. PVC Nonpressure Piping: Join according to ASTM D 2855.
- I. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
- J. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
- K. Plain-End Mechanical-Coupled Joints: Prepare, assemble, and test joints in accordance with manufacturer's written installation instructions.
- L. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.
- M. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 23 05 19 "Meters and Gages for HVAC Piping."

3.7 CHEMICAL TREATMENT

- A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:
 - 1. pH: **[9.0 to 10.5]** <Insert values>.
 - 2. "P" Alkalinity: **[100 to 500]** <Insert values> ppm.
 - 3. Boron: **[100 to 200]** <Insert values> ppm.

4. Chemical Oxygen Demand: Maximum of [100] <Insert value> ppm. Revise this value if closed system contains glycol.
 5. Corrosion Inhibitor:
 - a. Sodium Nitrate: [1000 to 1500] <Insert values> ppm.
 - b. Molybdate: [200 to 300] <Insert values> ppm.
 - c. Chromate: [200 to 300] <Insert values> ppm.
 - d. Sodium Nitrate Plus Molybdate: [100 to 200] <Insert values> ppm each.
 - e. Chromate Plus Molybdate: [50 to 100] <Insert values> ppm each.
 6. Soluble Copper: Maximum of [0.20] <Insert value> ppm.
 7. Tolyriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of [10] <Insert value> ppm.
 8. Total Suspended Solids: Maximum of [10] <Insert value> ppm.
 9. Ammonia: Maximum of [20] <Insert value> ppm.
 10. Free Caustic Alkalinity: Maximum of [20] <Insert value> ppm.
 11. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maximum of [1000] <Insert number> organisms/mL.
 - b. Total Anaerobic Plate Count: Maximum of [100] <Insert number> organisms/mL.
 - c. Nitrate Reducers: [100] <Insert number> organisms/mL.
 - d. Sulfate Reducers: Maximum of [zero] <Insert number> organisms/mL.
 - e. Iron Bacteria: Maximum of [zero] <Insert number> organisms/mL.
 12. <Insert other requirements if necessary>.
- B. Install bypass chemical feeders in each hydronic system where indicated.
1. Install in upright position with top of funnel not more than 48 inches above the floor.
 2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
 3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.
- C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
- D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.
- E. Fill systems that have antifreeze or glycol solutions with the following concentrations:
1. Hot-Water Heating Piping: Minimum of <Insert number> percent [ethylene] [propylene] glycol.
 2. Chilled-Water Piping: Minimum of <Insert number> percent [ethylene] [propylene] glycol.
 3. Dual-Temperature Heating and Cooling Water Piping: Minimum of <Insert number> percent [ethylene] [propylene] glycol.

4. Glycol Cooling-Water Piping: Minimum of <Insert number> percent [ethylene] [propylene] glycol.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION

SECTION 23 21 16

HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air-control devices.
3. Strainers.
4. Connectors.

B. Related Requirements:

1. Section 23 05 16 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
2. Section 23 05 23.11 "Globe Valves for HVAC Piping" for specification and installation requirements for globe valves common to most piping systems.
3. Section 23 05 23.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
4. Section 23 05 23.13 "Butterfly Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.
5. Section 23 05 23.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
6. Section 23 05 23.15 "Gate Valves for HVAC Piping" for specification and installation requirements for gate valves common to most piping systems.
7. Section 23 09 23.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
- B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Plastic Ball Valves:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: One-, two-, or three-piece CPVC or PVC to match piping.
3. Ball: Full-port CPVC or PVC to match piping.
4. Seats: PTFE.
5. Seals: EPDM.
6. End Connections: Socket, union, or flanged.
7. Handle Style: Tee shape.
8. CWP Rating: Equal to piping service.
9. Maximum Operating Temperature: Equal to piping service.
10. Comply with MSS SP-122.

B. Plastic Butterfly Valves:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: PVC or CPVC to match piping wafer type for installation between flanges.
3. Disc: EPDM-coated steel.
4. Seats: PTFE.
5. Handle Style: Locking lever.
6. CWP Rating: Equal to piping service.
7. Maximum Operating Temperature: Equal to piping service.

C. Plastic Check Valves:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

D. Bronze, Calibrated-Orifice, Balancing Valves:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

E. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 deg F.

F. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: **<Insert materials>**, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.

10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Diaphragm-Operated Safety Valves: ASME labeled.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: **<Insert materials>**, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

H. Automatic Flow-Control Valves:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Brass or ferrous metal.
3. Flow Control Assembly, provide either of the following:
 - a. Piston and Spring Assembly: **[Stainless steel] [Corrosion resistant]**, tamper proof, self-cleaning, and removable.
 - b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig differential pressure.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
8. Minimum CWP Rating: **[175 psig] [300 psig]**.
9. Maximum Operating Temperature: **[200 deg F] [250 deg F]**.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

C. Expansion Tanks:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested after taps are fabricated and shall be labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
4. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
5. Gage Glass: Full height with dual manual shutoff valves, [3/4-inch-] **<Insert dimension>** diameter gage glass, and slotted-metal glass guard.

D. [Diaphragm] [Bladder]-Type ASME Expansion Tanks:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. [Diaphragm] [Bladder]: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

E. Diaphragm-Type Non-ASME Expansion Tanks:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Tank: Carbon steel, rated for minimum 100-psig working pressure at minimum 200 deg F maximum operating temperature. Non-ASME construction.
3. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.

F. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

G. Coalescing-Type Air and Dirt Separators:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2. Tank: Fabricated steel tank; ASME constructed and stamped for 125-psig (862-kPa) working pressure and 270 deg F (130 deg C) maximum operating temperature.
3. Coalescing Medium: **[Copper]** **[Stainless steel]** **<Insert material>**.
4. Air Vent: Threaded to the top of the separator.
5. Inline Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; Class 150 flanged connections for NPS 2-1/2 (DN 65) and larger.
6. Blowdown Connection: Threaded to the bottom of the separator.
7. Size: Match system flow capacity.

H. Tangential-Type Air Separators:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.

I. In-Line Air Separators:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
3. Maximum Working Pressure: Up to 175 psig.
4. Maximum Operating Temperature: Up to 300 deg F.

J. Air Purgers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig.
4. Maximum Operating Temperature: 250 deg F.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, **[20]** **[40]** **[60]**-mesh strainer or perforated stainless-steel basket.
4. CWP Rating: 125 psig.

B. Basket Strainers:

1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: [40] [60]-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: [40] [60]-mesh startup strainer and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

2.4 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

B. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install [**throttling-duty**] [**calibrated-orifice, balancing**] valves at each branch connection to return main.
- C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

- E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.
- E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.
- F. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
 - 1. Install tank fittings that are shipped loose.
 - 2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.
- G. Install expansion tanks on the floor. Vent and purge air from hydronic system and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

SECTION 23 21 23

HYDRONIC PUMPS

(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections:

Section 03 30 00 – CAST-IN-PLACE CONCRETE

Section 03 30 53 – MISCELLANEOUS CAST-IN-PLACE CONCRETE

Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

Section 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

Section 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

Section 23 05 29 – HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

Section 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC

Section 23 05 48.13 – VIBRATION CONTROLS FOR HVAC

Section 23 22 12 – STEAM AND CONDENSATE HEATING PIPING

Section 23 22 16 – STEAM AND CONDENSATE PIPING SPECIALTIES

1.3 SUMMARY:

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Close-coupled, end-suction centrifugal pumps.
3. Separately coupled, horizontally mounted, in-line centrifugal pumps.
4. Separately coupled, vertically mounted, in-line centrifugal pumps.
5. Separately coupled, base-mounted, end-suction centrifugal pumps.
6. Separately coupled, base-mounted, double-suction centrifugal pumps.
7. Separately coupled, vertically mounted, double-suction centrifugal pumps.
8. Separately coupled, vertically mounted, turbine centrifugal pumps.
9. Wet-rotor pumps.
10. Automatic condensate pump units.

1.4 DEFINITIONS:

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

1.5 ACTION SUBMITTALS:

- A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
- B. Shop Drawings: For each pump.
 1. Show pump layout and connections.
 2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 3. Include diagrams for power, signal, and control wiring.

1.6 CLOSEOUT SUBMITTALS:

- A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1.7 MAINTENANCE MATERIAL SUBMITTALS:

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: [**One**] **<Insert number>** mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

- C. Capacities and Characteristics:

1. Capacity: **<Insert gpm>**.
2. Total Dynamic Head: **<Insert feet>**.
3. Maximum Operating Pressure: [**175 psig**] [**250 psig**] **<Insert psig>**.
4. Maximum Continuous Operating Temperature: [**225 deg. F**] [**250 deg. F**] **<Insert deg. F>**.
5. Inlet and Outlet Size: **<Insert NPS>**.
6. Impeller Size: **<Insert inches>**.
7. Motor Speed: **<Insert rpm>**.
8. Motor Horsepower: **<Insert value>**.
9. Electrical Characteristics:
 - a. Volts: [**120**] [**240**] [**208**] [**460**] **<Insert value>**.
 - b. Phase: [**Single**] [**Three**].
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

- D. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet [, **replaceable bronze wear rings,**] and threaded [**companion-flange**] [**union-end**] connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.

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3. Pump Shaft: [**Steel, with copper-alloy shaft sleeve**] [**Stainless steel**].
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [**Buna-N**] [**EPT**] [**Viton**] **<Insert material>** bellows and gasket. Include water slinger on shaft between motor and seal.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: [**Permanently lubricated ball bearings**] [**Oil lubricated; bronze-journal or thrust type**].

E. Motor: Single speed and rigidly mounted to pump casing.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
 - a. Enclosure: [**Open, drip proof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
 - b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
 - c. Motor Bearings: [**Permanently lubricated**] [**Grease-lubricated**] ball bearings.
 - d. Unusual Service Conditions:
 - 1) Ambient Temperature: **<Insert deg. C>**.
 - 2) Altitude: **<Insert feet>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
 - e. Efficiency: Premium efficient.
 - f. NEMA Design: **<Insert designation>**.
 - g. Service Factor: **<Insert value>**.

2.2 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- C. Capacities and Characteristics:

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1. Capacity: **<Insert gpm>**.
2. Total Dynamic Head: **<Insert feet>**.
3. Maximum Operating Pressure: 175 psig **<Insert psigPa>**.
4. Maximum Continuous Operating Temperature: **[225 deg. F] [250 deg. F] <Insert deg. F>**.
5. Inlet and Outlet Size: **<Insert NPS>**.
6. Impeller Size: **<Insert inches>**.
7. Motor Speed: **<Insert rpm>**.
8. Motor Horsepower: **<Insert value>**.
9. Electrical Characteristics:
 - a. Volts: **[120] [240] [208] [460] <Insert value>**.
 - b. Phase: **[Single] [Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

D. Pump Construction:

1. Casing: Radially split, cast iron, with **[replaceable bronze wear rings,]** drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and **[threaded companion-flange] [flanged]** connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: **[Steel, with copper-alloy shaft sleeve] [Stainless steel]**.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and **[Buna-N] [EPT]** bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: **[Permanently lubricated ball bearings] [Oil lubricated; bronze-journal or thrust type]**.

E. Motor: Single speed and rigidly mounted to pump casing with integral pump support.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
 - a. Enclosure: **[Open, drip proof] [Totally enclosed, fan cooled] [Totally enclosed, air over] [Open, externally ventilated] [Totally enclosed, nonventilated] [Severe duty] [Explosion proof] [Dust-ignition-proof machine]**.
 - b. Enclosure Materials: **[Cast iron] [Cast aluminum] [Rolled steel]**.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- c. Motor Bearings: [**Permanently lubricated**] [**Grease-lubricated**] ball bearings.
- d. Unusual Service Conditions:
 - 1) Ambient Temperature: **<Insert deg. C>**.
 - 2) Altitude: **<Insert feet>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
- e. Efficiency: Premium efficient.
- f. NEMA Design: **<Insert designation>**.
- g. Service Factor: **<Insert value>**.

2.3 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- C. Capacities and Characteristics:
 - 1. Capacity: **<Insert gpm>**.
 - 2. Total Dynamic Head: **<Insert feet>**.
 - 3. Maximum Operating Pressure: 175 psig **<Insert psig>**.
 - 4. Maximum Continuous Operating Temperature: [**225 deg. F**] [**250 deg. F**] **<Insert deg. F>**.
 - 5. Inlet and Outlet Size: **<Insert NPS>**.
 - 6. Impeller Size: **<Insert inches>**.
 - 7. Motor Speed: **<Insert rpm>**.
 - 8. Motor Horsepower: **<Insert value>**.
 - 9. Electrical Characteristics:
 - a. Volts: [**120**] [**240**] [**208**] [**460**] **<Insert value>**.
 - b. Phase: [**Single**] [**Three**].
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.
- D. Pump Construction:
 - 1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded [**companion-flange**] [**union-end**] connections.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps, not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: **[Steel, with copper-alloy shaft sleeve]** **[Stainless steel]**.
 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and **[Buna-N]** **[EPT]** **[Viton]** **<Insert material>** bellows and gasket. Include water slinger on shaft between motor and seal.
 5. Pump Bearings: **[Permanently lubricated ball bearings]** **[Oil lubricated; bronze-journal or thrust type]**.
- E. Shaft Coupling: **[Molded-rubber insert with interlocking spider]** **[Interlocking frame with interconnecting springs]** capable of absorbing vibration.
- F. Motor: Single speed and **[resiliently]** **[rigidly]** mounted to pump casing.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
 - a. Enclosure: **[Open, drip proof]** **[Totally enclosed, fan cooled]** **[Totally enclosed, air over]** **[Open, externally ventilated]** **[Totally enclosed, nonventilated]** **[Severe duty]** **[Explosion proof]** **[Dust-ignition-proof machine]**.
 - b. Enclosure Materials: **[Cast iron]** **[Cast aluminum]** **[Rolled steel]**.
 - c. Motor Bearings: **[Permanently lubricated]** **[Grease-lubricated]** ball bearings.
 - d. Unusual Service Conditions:
 - 1) Ambient Temperature: **<Insert deg. C>**.
 - 2) Altitude: **<Insert feet>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
 - e. Efficiency: Premium efficient.
 - f. NEMA Design: **<Insert designation>**.
 - g. Service Factor: **<Insert value>**.
- 2.4 SEPARATELY COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS:
- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.
- C. Capacities and Characteristics:
1. Capacity: **<Insert gpm>**.
 2. Total Dynamic Head: **<Insert feet>**.
 3. Maximum Operating Pressure: **[175 psig] [250 psig] <Insert psig>**.
 4. Maximum Continuous Operating Temperature: **[225 deg. F] [250 deg. F] <Insert deg. F>**.
 5. Inlet and Outlet Size: **<Insert NPS>**.
 6. Impeller Size: **<Insert inches>**.
 7. Motor Speed: **<Insert rpm>**.
 8. Motor Horsepower: **<Insert value>**.
 9. Electrical Characteristics:
 - a. Volts: **[120] [240] [208] [460] <Insert value>**.
 - b. Phase: **[Single] [Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.
- D. Pump Construction:
1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet **[, replaceable bronze wear rings,]** and threaded **[companion-flange] [union-end]** connections.
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps, not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: **[Steel, with copper-alloy shaft sleeve] [Stainless steel]**.
 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and **[Buna-N] [EPT] [Viton] <Insert material>** bellows and gasket. Include water slinger on shaft between motor and seal.
 5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 6. Pump Bearings: **[Permanently lubricated ball bearings] [Oil lubricated; bronze-journal or thrust type]**.
- E. Shaft Coupling: Axially split spacer coupling.
- F. Motor: Single speed and rigidly mounted to pump casing with lifting eyebolt and supporting lugs in motor enclosure.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
 - a. Enclosure: [**Open, drip proof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
 - b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
 - c. Motor Bearings: [**Permanently lubricated**] [**Grease-lubricated**] ball bearings.
 - d. Unusual Service Conditions:
 - 1) Ambient Temperature: <**Insert deg. C**>.
 - 2) Altitude: <**Insert feet**> above sea level.
 - 3) High humidity.
 - 4) <**Insert conditions**>.
 - e. Efficiency: Premium efficient.
 - f. NEMA Design: <**Insert designation**>.
 - g. Service Factor: <**Insert value**>.

2.5 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Armstrong Pumps, Inc.
 2. ITT Corporation.
 3. TACO Comfort Solutions, Inc.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.
- C. Pump Construction:
 1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections.
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps, not frequency-drive controlled, trim impeller to match specified performance.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3. Pump Shaft: Stainless steel.
 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Viton bellows and gasket.
 5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.
- D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor. EPDM coupling sleeve for variable-speed applications.
- E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
- F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
- G. Motor: Single speed, secured to mounting frame, with adjustable alignment.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
 - a. Enclosure: Totally enclosed, fan cooled.
 - b. Enclosure Materials: Cast iron.
 - c. Motor Bearings: Permanently lubricated ball bearings.
 - d. Efficiency: Premium efficient.
 - e. Service Factor: 1.15.
- 2.6 SEPARATELY COUPLED, BASE-MOUNTED, DOUBLE-SUCTION CENTRIFUGAL PUMPS:
- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.
- C. Capacities and Characteristics:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Capacity: <Insert gpm>.
2. Total Dynamic Head: <Insert feet>.
3. Maximum Operating Pressure: [175 psig] [250 psig] <Insert psig>.
4. Maximum Continuous Operating Temperature: [225 deg. F] [250 deg. F] <Insert deg. F>.
5. Inlet and Outlet Size: <Insert NPS>.
6. Impeller Size: <Insert inches>.
7. Motor Speed: <Insert rpm>.
8. Motor Horsepower: <Insert value>.
9. Electrical Characteristics:
 - a. Volts: [120] [240] [208] [460] <Insert value>.
 - b. Phase: [Single] [Three].
 - c. Hertz: 60.
 - d. Full-Load Amperes: <Insert value>.
 - e. Minimum Circuit Ampacity: <Insert value>.
 - f. Maximum Overcurrent Protection: <Insert amperage>.

D. Pump Construction:

1. Casing: [Radially] [Horizontally] split, cast iron, with [replaceable bronze wear rings,] threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and ASME B16.1, [Class 125] [Class 250] flanges. [Casing supports shall allow removal and replacement of impeller without disconnecting piping.]
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps, not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: Stainless steel.
 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [Buna-N] [EPT] [Viton] <Insert material> bellows and gasket.
 5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.
- E. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. [Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor.] [EPDM coupling sleeve for variable-speed applications.]
- F. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- G. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
- H. Motor: Single speed, secured to mounting frame, with adjustable alignment.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
 - a. Enclosure: [**Open, drip proof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
 - b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
 - c. Motor Bearings: Grease lubricated.
 - d. Unusual Service Conditions:
 - 1) Ambient Temperature: <**Insert deg. C**>.
 - 2) Altitude: <**Insert feet**> above sea level.
 - 3) High humidity.
 - 4) <**Insert conditions**>.
 - e. Efficiency: Premium efficient.
 - f. NEMA Design: <**Insert designation**>.
 - g. Service Factor: <**Insert value**>.

2.7 SEPARATELY COUPLED, VERTICALLY MOUNTED, DOUBLE-SUCTION CENTRIFUGAL PUMPS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.
- C. Capacities and Characteristics:
 - 1. Capacity: <**Insert gpm**>.
 - 2. Total Dynamic Head: <**Insert feet**>.
 - 3. Maximum Operating Pressure: [**175 psig**] [**250 psig**] <**Insert psig**>.
 - 4. Maximum Continuous Operating Temperature: [**225 deg. F**] [**250 deg. F**] <**Insert deg. F**>.
 - 5. Inlet and Outlet Size: <**Insert NPS**>.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

6. Impeller Size: **<Insert inches>**.
7. Motor Speed: **<Insert rpm>**.
8. Motor Horsepower: **<Insert value>**.
9. Electrical Characteristics:
 - a. Volts: **[120] [240] [208] [460] <Insert value>**.
 - b. Phase: **[Single] [Three]**.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

D. Pump Construction:

1. Casing: Radially split, cast iron, with [**replaceable bronze wear rings,**] threaded gage tappings at inlet and outlet, drain plug at bottom of volute, mounting support, and ASME B16.1, [**Class 125**] [**Class 250**] flanges.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps, not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [**Buna-N**] [**EPT**] [**Viton**] **<Insert material>** bellows and gasket.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

E. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration.

F. Motor: Single speed and secured to casing.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 – COMMON MOTER REQUIREMENTS FOR HVAC EQUIPMENT.
 - a. Enclosure: [**Open, drip proof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
 - b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- c. Motor Bearings: Grease lubricated.
- d. Unusual Service Conditions:
 - 1) Ambient Temperature: **<Insert deg. C>**.
 - 2) Altitude: **<Insert feet>** above sea level.
 - 3) High humidity.
 - 4) **<Insert conditions>**.
- e. Efficiency: Premium efficient.
- f. NEMA Design: **<Insert designation>**.
- g. Service Factor: **<Insert value>**.

2.8 SEPARATELY COUPLED, VERTICALLY MOUNTED, TURBINE CENTRIFUGAL PUMPS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Factory-assembled and -tested, [**single-stage**] [**multistage**], centrifugal, impeller-between-bearings, end-suction pump as defined in HI 2.1-2.2 and HI 2.3; designed for installation with pump and motor shafts mounted vertically and projecting into a sump.
- C. Capacities and Characteristics:
 - 1. Capacity: **<Insert gpm>**.
 - 2. Total Dynamic Head: **<Insert feet>**.
 - 3. Minimum Static Head: **<Insert feet>**.
 - 4. Maximum Operating Pressure: 175 psig **<Insert psig>**.
 - 5. Maximum Continuous Operating Temperature: 200 deg. F **<Insert deg. F>**.
 - 6. Outlet Size: **<Insert NPS>**.
 - 7. Impeller Size: **<Insert inches>**.
 - 8. Motor Speed: **<Insert rpm>**.
 - 9. Motor Horsepower: **<Insert value>**.
 - 10. Electrical Characteristics:
 - a. Volts: [**120**] [**240**] [**208**] [**460**] **<Insert value>**.
 - b. Phase: [**Single**] [**Three**].
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.
- D. Pump Construction:
 - 1. Pump Bowl: Cast iron, with [**cone**] [**basket**] strainer [, **replaceable bronze wear ring,**] and suction bell. [**Water passages of intermediate bowls shall be coated with porcelain enamel.**]

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced and keyed to shaft. For pumps, not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: [**Carbon**] [**Stainless**] steel sized according to manufacturer's requirements.
 4. Pump Bearings: Water-lubricated bronze and rubber sleeve bearings in cast-iron housing.
 5. Pump Column: ASTM A 53/A 53M, Grade B steel pipe.
 6. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [**Buna-N**] [**EPT**] bellows and gasket. Include water slinger on shaft between motor and seal.
 7. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
- E. Shaft Coupling: Keyed with locking collets.
- F. Discharge Head: ASME B16.1, [**Class 125**] [**Class 250**] discharge flange with threaded gage tapping. Top of discharge head shall have a registered fit to accurately locate the driver.
- G. Drive Ratchet: Nonreversing ratchet.
- H. Hollow Shaft Motor: Single speed and secured to discharge head.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
 - a. Enclosure: [**Open, drip proof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
 - b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
 - c. Motor Bearings: Grease lubricated.
 - d. Unusual Service Conditions:
 - 1) Ambient Temperature: <**Insert deg. C**>.
 - 2) Altitude: <**Insert feet**> above sea level.
 - 3) High humidity.
 - 4) <**Insert conditions**>.
 - e. Efficiency: Premium efficient.
 - f. NEMA Design: <**Insert designation**>.
 - g. Service Factor: <**Insert value**>.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.9 WET-ROTOR PUMPS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Factory-assembled and -tested, wet-rotor pump.
- C. Capacities and Characteristics:
 - 1. Capacity: **<Insert gpm>**.
 - 2. Total Dynamic Head: **<Insert feet>**.
 - 3. Maximum Operating Pressure: 150 psig **<Insert psig>**.
 - 4. Maximum Continuous Operating Temperature: [225 deg. F] [230 deg. F] **<Insert deg. F>**.
 - 5. Inlet and Outlet Size: **<Insert NPS>**.
 - 6. Impeller Size: **<Insert inches>**.
 - 7. Motor Speed: **<Insert rpm>**.
 - 8. Motor Horsepower: **<Insert value>**.
 - 9. Electrical Characteristics:
 - a. Volts: [120] **<Insert value>**.
 - b. Phase: [Single] [Three].
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.
- D. Pump Construction:
 - 1. Body: [100 percent lead-free bronze] [Stainless steel] [Cast iron].
 - 2. Impeller: [Polypropylene] [Noryl].
 - 3. Pump Shaft: [Ceramic] [Stainless steel].
 - 4. Bearings. Double-sintered carbon.
- E. Motor: [Single] [Three] speed.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
 - a. Efficiency: Premium efficient.
 - b. NEMA Design: **<Insert designation>**.
 - c. Service Factor: **<Insert value>**.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.10 AUTOMATIC CONDENSATE PUMP UNITS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch-minimum, electrical power cord with plug.
- C. Capacities and Characteristics:
 - 1. Capacity: **<Insert gpm>**.
 - 2. Total Dynamic Head: **<Insert feet>**.
 - 3. Maximum Height to Inlet: **<Insert inches>**.
 - 4. Inlet and Outlet Size: **<Insert NPS>**.
 - 5. Motor Speed: **<Insert rpm>**.
 - 6. Motor Horsepower: **<Insert value>**.
 - 7. Electrical Characteristics:
 - a. Volts: **[120] <Insert value>**.
 - b. Phase: Single.
 - c. Hertz: 60.
 - d. Full-Load Amperes: **<Insert value>**.
 - e. Minimum Circuit Ampacity: **<Insert value>**.
 - f. Maximum Overcurrent Protection: **<Insert amperage>**.

2.11 PUMP SPECIALTY FITTINGS:

- A. Suction Diffuser:
 - 1. Angle pattern.
 - 2. **[175-psig] [300-psig]** pressure rating, **[cast] [ductile]**-iron body and end cap, pump-inlet fitting.
 - 3. Bronze startup and bronze or stainless-steel permanent strainers.
 - 4. Bronze or stainless-steel straightening vanes.
 - 5. Drain plug.
 - 6. Factory-fabricated support.
- B. Triple-Duty Valve:
 - 1. Angle or straight pattern.
 - 2. **[175-psig] [300-psig]** pressure rating, **[cast] [ductile]**-iron body, pump-discharge fitting.
 - 3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
 - 4. Brass gage ports with integral check valve and orifice for flow measurement.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION:

- A. Comply with **[HI 1.4]** **[and]** **[HI 2.4]**.
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.
- E. Equipment Mounting:
 - 1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in **[Section 03 30 00 – CAST-IN-PLACE CONCRETE]** **[Section 03 30 53 – MISCELLANEOUS CAST-IN-PLACE CONCRETE.]**
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC.
 - 3. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 – VIBRATION CONTROLS FOR HVAC.
- F. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and **[elastomeric hangers]** **[spring hangers]** **[spring hangers with vertical-limit stop]** of size required to support weight of in-line pumps.
 - 1. Comply with requirements for seismic-restraint devices specified in Section 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Comply with requirements for hangers and supports specified in Section 23 05 29 – HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT.

3.3 ALIGNMENT:

- A. **[Engage a factory-authorized service representative to perform] [Perform]** alignment service.
- B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- C. Comply with pump and coupling manufacturers' written instructions.
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS:

- A. Comply with requirements for piping specified in Section 23 22 13 – STEAM AND CONDENSATE HEATING PIPING and Section 23 22 16 – STEAM AND CONDENSATE PIPING SPECIALTIES. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to pump, allow space for service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install **[check, shutoff, and throttling valves] [check valve and throttling valve with memory stop] [triple-duty valve]** on discharge side of pumps.
- F. Install **[Y-type strainer] [suction diffuser]** and shutoff valve on suction side of pumps.
- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- H. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping or install single gage with multiple-input selector valve.
- I. Install check valve and gate or ball valve on each condensate pump unit discharge.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- J. Ground equipment according to Section 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- K. Connect wiring according to Section 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.5 STARTUP SERVICE:

- A. **[Engage a factory-authorized service representative to perform] [Perform]** startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 5. Prime pump by opening suction valves and closing drains and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

3.6 DEMONSTRATION:

- A. **[Engage a factory-authorized service representative to train] [Train]** Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

SECTION 23 23 00

REFRIGERANT PIPING

(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections:

Section 08 31 13 – ACCESS DOORS AND FRAMES

Section 23 05 17 – SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

Section 23 05 18 – ESCUTCHEONS FOR HVAC PIPING

Section 23 05 29 – HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

Section 23 05 53 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

Section 23 09 23 – DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

Section 23 09 93.11 – SEQUENCE OF OPERATIONS FOR HVAC DDC

1.3 SUMMARY:

- A. Section Includes:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Refrigerant pipes and fittings.
2. Refrigerant piping valves and specialties.
3. Refrigerants.

1.4 ACTION SUBMITTALS:

A. Product Data: For each type of valve, refrigerant piping, and piping specialty.

1. Include pressure drop, based on manufacturer's test data, for the following:
 - a. Thermostatic expansion valves.
 - b. Solenoid valves.
 - c. Hot-gas bypass valves.
 - d. Filter dryers.
 - e. Strainers.
 - f. Pressure-regulating valves.

B. Sustainable Design Submittals:

1. [<Double click to insert sustainable design text for HVAC units.>](#)

C. Shop Drawings:

1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
3. Show interface and spatial relationships between piping and equipment.
4. Shop Drawing Scale: [**1/4-inch equals 1 foot**] **<Insert value>**.

1.5 INFORMATIONAL SUBMITTALS:

- A. Welding certificates.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS:

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

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1.7 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.8 PRODUCT STORAGE AND HANDLING:

- A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS:

- A. Line Test Pressure for Refrigerant R-134a:
 - 1. Suction Lines for Air-Conditioning Applications: 115 psig.
 - 2. Suction Lines for Heat-Pump Applications: 225 psig.
 - 3. Hot-Gas and Liquid Lines: 225 psig.
- B. Line Test Pressure for Refrigerant R-407C:
 - 1. Suction Lines for Air-Conditioning Applications: 230 psig.
 - 2. Suction Lines for Heat-Pump Applications: 380 psig.
 - 3. Hot-Gas and Liquid Lines: 380 psig.
- C. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
 - 2. Suction Lines for Heat-Pump Applications: 535 psig.
 - 3. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS:

- A. Copper Tube: [ASTM B 88, Type K or L] [ASTM B 280, Type ACR].
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.

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- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8/A5.8M.
- F. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Working Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg. F.

2.3 STEEL PIPE AND FITTINGS:

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as selected in piping application articles.
- B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.
- C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.
- D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- E. Flanged Unions:
 - 1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
 - 2. Gasket: Fiber asbestos free.
 - 3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
 - 4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
 - 5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 6. Pressure Rating: Factory test at minimum 400 psig.
 - 7. Maximum Operating Temperature: 330 deg. F.
- F. Flexible Connectors:
 - 1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket.
 - 2. End Connections:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. NPS 2 and Smaller: With threaded-end connections.
 - b. NPS 2-1/2 and Larger: With flanged-end connections.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 4. Pressure Rating: Factory test at minimum 500 psig.
 5. Maximum Operating Temperature: 250 deg. F.

2.4 VALVES AND SPECIALTIES:

A. Diaphragm Packless Valves:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
3. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
4. Operator: Rising stem and hand wheel.
5. Seat: Nylon.
6. End Connections: Socket, union, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg. F.

B. Packed-Angle Valves:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body and Bonnet: Forged brass or cast bronze.
3. Packing: Molded stem, back seating, and replaceable under pressure.
4. Operator: Rising stem.
5. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
6. Seal Cap: Forged-brass or valox hex cap.
7. End Connections: Socket, union, threaded, or flanged.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg. F.

C. Check Valves:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
3. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
4. Piston: Removable polytetrafluoroethylene seat.
5. Closing Spring: Stainless steel.
6. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
7. End Connections: Socket, union, threaded, or flanged.
8. Maximum Opening Pressure: 0.50 psig.

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9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 275 deg. F.

D. Service Valves:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Forged brass with brass cap including key end to remove core.
3. Core: Removable ball-type check valve with stainless-steel spring.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Copper spring.
6. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body and Bonnet: Plated steel.
3. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Threaded.
6. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and [24] [115] [208]-V ac coil.
7. Working Pressure Rating: 400 psig.
8. Maximum Operating Temperature: 240 deg. F.

F. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
3. Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Threaded.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg. F.

G. Thermostatic Expansion Valves: Comply with AHRI 750.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body, Bonnet, and Seal Cap: Forged brass or steel.
3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Packing and Gaskets: Non-asbestos.
5. Capillary and Bulb: Copper tubing filled with refrigerant charge.
6. Suction Temperature: **[40 deg. F]** **<Insert temperature>**.

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7. Superheat: [**Adjustable**] [**Nonadjustable**].
8. Reverse-flow option (for heat-pump applications).
9. End Connections: Socket, flare, or threaded union.
10. Working Pressure Rating: [**700 psig**] [**450 psig**] <Insert value>.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body, Bonnet, and Seal Cap: Ductile iron or steel.
3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Packing and Gaskets: Non-asbestos.
5. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
6. Seat: Polytetrafluoroethylene.
7. Equalizer: [**Internal**] [**External**].
8. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter and [**24**] [**115**] [**208**]-V ac coil.
9. End Connections: Socket.
10. Set Pressure: <Insert psig>.
11. Throttling Range: Maximum 5 psig.
12. Working Pressure Rating: 500 psig.
13. Maximum Operating Temperature: 240 deg. F.

I. Straight-Type Strainers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Welded steel with corrosion-resistant coating.
3. Screen: 100-mesh stainless steel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg. F.

J. Angle-Type Strainers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Forged brass or cast bronze.
3. Drain Plug: Brass hex plug.
4. Screen: 100-mesh monel.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg. F.

K. Moisture/Liquid Indicators:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

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2. Body: Forged brass.
3. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
4. Indicator: Color coded to show moisture content in parts per million (ppm).
5. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
6. End Connections: Socket or flare.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg. F.

L. Replaceable-Core Filter Dryers: Comply with AHRI 730.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
3. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Desiccant Media: Activated [alumina] [charcoal].
5. Designed for reverse flow (for heat-pump applications).
6. End Connections: Socket.
7. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
8. Maximum Pressure Loss: [2 psig] <Insert value>.
9. Rated Flow: <Insert tons>.
10. Working Pressure Rating: 500 psig.
11. Maximum Operating Temperature: 240 deg. F.

M. Permanent Filter Dryers: Comply with AHRI 730.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body and Cover: Painted-steel shell.
3. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Desiccant Media: Activated [alumina] [charcoal].
5. Designed for reverse flow (for heat-pump applications).
6. End Connections: Socket.
7. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
8. Maximum Pressure Loss: [2 psig] <Insert value>.
9. Rated Flow: <Insert tons>.
10. Working Pressure Rating: 500 psig.
11. Maximum Operating Temperature: 240 deg. F.

N. Mufflers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Welded steel with corrosion-resistant coating.

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3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg. F.

O. Receivers: Comply with AHRI 495.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
3. Comply with UL 207; listed and labeled by an NRTL.
4. Body: Welded steel with corrosion-resistant coating.
5. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
6. End Connections: Socket or threaded.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg. F.

P. Liquid Accumulators: Comply with AHRI 495.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Body: Welded steel with corrosion-resistant coating.
3. End Connections: Socket or threaded.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg. F.

2.5 REFRIGERANTS:

A. ASHRAE 34, R-134a: Tetrafluoroethane.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

B. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

C. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-134a:

- A. Suction Lines [**NPS 1-1/2 and Smaller**] <Insert pipe size range> for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
- B. Suction Lines [**NPS 4 and Smaller**] [**NPS 2 to NPS 4**] <Insert pipe size range> for Conventional Air-Conditioning Applications: Copper, [**Type ACR**] [**Type L**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
- C. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications]: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
- D. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications]: Copper, [**Type ACR**] [**Type K**] [**Type L**], drawn-temper tubing and wrought-copper fittings with soldered joints.
- E. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications]:
 - 1. [**NPS 1-1/2 and Smaller**] <Insert pipe size range>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
 - 2. [**NPS 1-1/2 and Smaller**] <Insert pipe size range>: Copper, [**Type ACR**] [**Type K**] [**Type L**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
 - 3. [**NPS 4**] <Insert pipe size>: Copper, [**Type ACR**] [**Type K**] [**Type L**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
- F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.
- G. Safety-Relief-Valve Discharge Piping: Copper, [**Type ACR**] [**Type K**] [**Type L**], drawn-temper tubing and wrought-copper fittings with soldered joints.
- H. Safety-Relief-Valve Discharge Piping:
 - 1. [**NPS 1-1/2 and Smaller**] <Insert pipe size range>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
 - 2. [**NPS 1-1/2 and Smaller**] <Insert pipe size range>: Copper, [**Type ACR**] [**Type L**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
 - 3. [**NPS 4**] <Insert pipe size>: Copper, [**Type ACR**] [**Type K**] [**Type L**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-407C:

- A. Suction Lines [**NPS 1-1/2 and Smaller**] <Insert pipe size range> for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
- B. Suction Lines [**NPS 4 and Smaller**] [**NPS 2 to NPS 4**] <Insert pipe size range> for Conventional Air-Conditioning Applications: Copper, [**Type ACR**] [**Type L**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
- C. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications]: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
- D. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications]: Copper, [**Type ACR**] [**Type K**] [**Type L**], drawn-temper tubing and wrought-copper fittings with soldered joints.
- E. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications]:
 - 1. [**NPS 1 and Smaller**] <Insert pipe size range>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
 - 2. [**NPS 1 and Smaller**] <Insert pipe size range>: Copper, [**Type ACR**] [**Type L**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
 - 3. [**NPS 1-1/4 to NPS 2**] <Insert pipe size range>: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
 - 4. [**NPS 4**] <Insert pipe size range>: Copper, [**Type ACR**] [**Type K**] [**Type L**], drawn-temper tubing and wrought-copper fittings with soldered joints.
- F. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.
- G. Safety-Relief-Valve Discharge Piping: Copper, [**Type ACR**] [**Type K**] [**Type L**], drawn-temper tubing and wrought-copper fittings with soldered joints.
- H. Safety-Relief-Valve Discharge Piping:
 - 1. [**NPS 1 and Smaller**] <Insert pipe size range>: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
 - 2. [**NPS 1 and Smaller**] <Insert pipe size range>: Copper, [**Type ACR**] [**Type L**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
 - 3. [**NPS 1-1/4 to NPS 2**] <Insert pipe size range>: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

4. [NPS 4] <Insert pipe size>: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with soldered joints.

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-410A:

- A. Suction Lines [NPS 1-1/2 and Smaller] <Insert pipe size range> for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
- B. Suction Lines [NPS 3-1/2 and Smaller] [NPS 2 to NPS 3-1/2] <Insert pipe size range> for Conventional Air-Conditioning Applications: Copper, [Type ACR] [Type L], drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
- C. Suction Lines [NPS 4 and Smaller] <Insert pipe size range> for Conventional Air-Conditioning Applications: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with soldered joints.
- D. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications]: Copper, [Type ACR] [Type L], annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
- E. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications]: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
- F. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications]: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
- G. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications]: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.
- H. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications]:
 1. [NPS 5/8 and Smaller] <Insert pipe size range>: Copper, [Type ACR] [Type L], annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
 2. [NPS 3/4 to NPS 1 and Smaller] <Insert pipe size range>: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
 3. [NPS 1-1/4 and Smaller] <Insert pipe size range>: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

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4. [NPS 1-1/2 to NPS 2] <Insert pipe size range>: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.
 - I. Hot-Gas and Liquid Lines [, and Suction Lines for Heat-Pump Applications] [NPS 2 to NPS 4] <Insert pipe size range>: Schedule 40, black-steel and wrought-steel fittings with welded joints.
 - J. Safety-Relief-Valve Discharge Piping: Copper, [Type ACR] [Type L], annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
 - K. Safety-Relief-Valve Discharge Piping: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
 - L. Safety-Relief-Valve Discharge Piping: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
 - M. Safety-Relief-Valve Discharge Piping: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.
 - N. Safety-Relief-Valve Discharge Piping:
 1. [NPS 5/8 and Smaller] <Insert pipe size range>: Copper, [Type ACR] [Type L], annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
 2. [NPS 3/4 to NPS 1 and Smaller] <Insert pipe size range>: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with [brazed] [or] [soldered] joints.
 3. [NPS 1-1/4 and Smaller] <Insert pipe size range>: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
 4. [NPS 1-1/2 to NPS 2] <Insert pipe size range>: Copper, [Type ACR] [Type K] [Type L], drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.
 - O. Safety-Relief-Valve Discharge Piping [NPS 2 to NPS 4] <Insert pipe size range>: Schedule 40, black-steel and wrought-steel fittings with welded joints.
- 3.4 VALVE AND SPECIALTY APPLICATIONS:
- A. Install [diaphragm packless] [packed-angle] valves in suction and discharge lines of compressor.
 - B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install [**diaphragm packless**] [**packed-angle**] valves on inlet and outlet side of filter dryers.
- E. Install a full-size, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Hot-gas bypass valves.
 - 4. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve [**, and in the suction line at the compressor**].
- L. Install receivers sized to accommodate pump-down charge.
- M. Install flexible connectors at compressors.

3.5 PIPING INSTALLATION:

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.

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- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Refer to Section 23 09 23 – DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC and Section 23 09 93.11 – SEQUENCE OF OPERATIONS FOR HVAC DDC for solenoid valve controllers, control wiring, and sequence of operation.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 08 31 13 – ACCESS DOORS AND FRAMES if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- O. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
1. Shot blast the interior of piping.
 2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
 3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
 4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
 5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
 6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.
- R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- S. Identify refrigerant piping and valves according to Section 23 05 53 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT.
- T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 – SLEEVES AND SLEEVE SEALS FOR HVAC PIPING.
- U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 05 17 – SLEEVES AND SLEEVE SEALS FOR HVAC PIPING.
- V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 05 18 – ESCUTCHEONS FOR HVAC PIPING.

3.6 PIPE JOINT CONSTRUCTION:

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

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- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.
- F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and to restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.
- H. Welded Joints: Construct joints according to AWS D10.12M/D10.12.
- I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 HANGERS AND SUPPORTS:

- A. Comply with requirements for pipe hangers and supports specified in Section 23 05 29 – HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT.
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:
 - 1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4-inch.
 - 2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4-inch.
 - 3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4- inch.

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4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8-inch.
 5. NPS 1-1/2: Maximum span, 96 inches; minimum rod, 3/8-inch.
 6. NPS 2: Maximum span, 96 inches; minimum rod, 3/8-inch.
 7. NPS 2-1/2: Maximum span, 108 inches; minimum rod, 3/8-inch.
 8. NPS 3: Maximum span, 10 feet; minimum rod, 3/8-inch.
 9. NPS 4: Maximum span, 12 feet; minimum rod, 1/2- inch.
- D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 2: Maximum span, 10 feet; minimum rod, 3/8-inch.
 2. NPS 2-1/2: Maximum span, 11 feet; minimum rod, 3/8-inch.
 3. NPS 3: Maximum span, 12 feet; minimum rod, 3/8-inch.
 4. NPS 4: Maximum span, 14 feet; minimum rod, 1/2- inch.
- E. Support multifloor vertical runs at least at each floor.

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
1. Comply with ASME B31.5, Chapter VI.
 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.
- B. Prepare test and inspection reports.

3.9 SYSTEM CHARGING:

- A. Charge system using the following procedures:
1. Install core in filter dryers after leak test but before evacuation.
 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

4. Charge system with a new filter-dryer core in charging line.

3.10 ADJUSTING:

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 1. Open shutoff valves in condenser water circuit.
 2. Verify that compressor oil level is correct.
 3. Open compressor suction and discharge valves.
 4. Open refrigerant valves except bypass valves that are used for other purposes.
 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 23 25 13

WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS
(FILED SUB-BID REQUIRED AS PART OF SECTION 3 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY:

- A. Section includes the following water treatment for closed-loop hydronic systems:
 - 1. **[Manual] [Automatic]** chemical-feed equipment.
 - 2. Chemicals.
- B. Related Requirements:
 - 1. Section 23 25 33 "HVAC Makeup-Water Filtration Equipment" for water softeners, RO equipment, and filtration equipment.

1.4 DEFINITIONS:

- A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- B. RO: Reverse osmosis.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- C. TSS: Total suspended solids are solid materials, including organic and inorganic, that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.5 ACTION SUBMITTALS:

- A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
 - 1. Bypass feeders.
 - 2. Water meters.
 - 3. Inhibitor injection timers.
 - 4. pH controllers.
 - 5. TSS controllers.
 - 6. Chemical solution tanks.
 - 7. Injection pumps.
 - 8. Chemical test equipment.
 - 9. Chemical material safety data sheets.
- B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to hydronic systems.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include diagrams for power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS:

- A. Seismic Qualification Certificates: For components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- C. Field quality-control reports.
- D. Other Informational Submittals:
 - 1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Water Analysis: Illustrate water quality available at Project site.

1.7 CLOSEOUT SUBMITTALS:

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE:

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

1.9 MAINTENANCE SERVICE:

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion and scale formation for hydronic piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:
 1. Initial water analysis and HVAC water-treatment recommendations.
 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 3. Periodic field service and consultation.
 4. Customer report charts and log sheets.
 5. Laboratory technical analysis.
 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2.2 PERFORMANCE REQUIREMENTS:

- A. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics,

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operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including **[hot-water heating] [chilled water] [dual-temperature water] [and] [glycol cooling]**, shall have the following water qualities:

1. pH: Maintain a value within **[9.0 to 10.5] <Insert range>**.
2. "P" Alkalinity: Maintain a value within **[100 to 500] <Insert range>** ppm.
3. Boron: Maintain a value within **[100 to 200] <Insert range>** ppm.
4. Chemical Oxygen Demand: Maintain a maximum value of **[100] <Insert number>** ppm.
5. Soluble Copper: Maintain a maximum value of **[0.20] <Insert number>** ppm.
6. TSS: Maintain a maximum value of **[10] <Insert number>** ppm.
7. Ammonia: Maintain a maximum value of **[20] <Insert number>** ppm.
8. Free Caustic Alkalinity: Maintain a maximum value of **[20] <Insert number>** ppm.
9. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of **[1000] <Insert number>** organisms/mL.
 - b. Total Anaerobic Plate Count: Maintain a maximum value of **[100] <Insert number>** organisms/mL.
 - c. Nitrate Reducers: Maintain a maximum value of **[100] <Insert number>** organisms/mL.
 - d. Sulfate Reducers: Maintain a maximum value of **[zero] <Insert number>** organisms/mL.
 - e. Iron Bacteria: Maintain a maximum value of **[zero] <Insert number>** organisms/mL.
10. **<Insert other requirements if necessary>**.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT:

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: **[2 gal.] [5 gal.] <Insert value>**.
2. Minimum Working Pressure: **[125 psig] [175 psig] <Insert value>**.

2.4 AUTOMATIC CHEMICAL-FEED EQUIPMENT:

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.

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2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Threaded.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Water Meter:

1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 100 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Threaded.
7. Control: Low-voltage signal capable of transmitting 1000 feet.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Water Meter:

1. AWWA C701, turbine-type, totalization meter.
2. Body: [**Bronze**] [**Epoxy-coated cast iron**].
3. Minimum Working-Pressure Rating: 150 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Flanged.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: [**30 gal.**] [**50 gal.**] [**120 gal.**] <Insert value>.

E. Chemical Solution Injection Pumps:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
 2. Adjustable flow rate.
 3. Metal and thermoplastic construction.
 4. Built-in relief valve.
 5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
 6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.
- G. Injection Assembly:
1. Quill: Minimum NPS 1/2 with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
 2. Ball Valve: **[Three]** **[Two]**-piece, stainless steel; selected to fit quill.
 3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
 4. Assembly Pressure/Temperature Rating: Minimum 600 psig at 200 deg. F.

2.5 CHEMICALS:

- A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS:

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION:

- A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install water testing equipment on wall near water chemical application equipment.
- D. Install interconnecting control wiring for chemical treatment controls and sensors.
- E. Mount sensors and injectors in piping circuits.
- F. Bypass Feeders: Install in closed hydronic systems, including [**hot-water heating**] [**chilled water**] [**dual-temperature water**] [**and**] [**glycol cooling**], and equipped with the following:
 - 1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 2. Install water meter in makeup-water supply.
 - 3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
 - 5. Install a swing check on the inlet after the isolation valve.

3.3 CONNECTIONS:

- A. Where installing piping adjacent to equipment, allow space for service and maintenance.
- B. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 23 21 16 "Hydronic Piping Specialties."
- C. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 23 05 23.11 "Globe Valves for HVAC Piping," Section 23 05 23.12 "Ball Valves for HVAC Piping," Section 23 05 23.13 "Butterfly Valves for HVAC Piping," and Section 23 05 23.15 "Gate Valves for HVAC Piping."
- D. Comply with requirements in Section 22 11 19 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.
- E. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.
- F. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- G. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL:

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections [**with the assistance of a factory-authorized service representative**]:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 - 7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 - 8. Repair leaks and defects with new materials and retest piping until no leaks exist.
- C. Equipment will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. At [**four**] [**six**] [**eight**] <Insert number>-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to "Performance Requirements" Article.
- F. Comply with ASTM D 3370 and with the following standards:
 - 1. Silica: ASTM D 859.
 - 2. Acidity and Alkalinity: ASTM D 1067.
 - 3. Iron: ASTM D 1068.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

4. Water Hardness: ASTM D 1126.

3.5 DEMONSTRATION:

- A. **[Engage a factory-authorized service representative to train]** **[Train]** Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.
- B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION

SECTION 23 31 10

DUCTWORK AND ACCESSORIES
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Filed Sub-Bid Requirements: As provided under Section 23 00 01 – HVAC Filed Sub-Bid Requirements, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 01 – General Requirements.
- B. Work of this Filed Sub-Bid includes all drawings and all individual specification sections listed in Section 23 00 01 – HVAC Filed Sub-Bid Requirements.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY

- A. Section Includes:
 - 1. Sheet metal ducts:
 - a. Single-wall rectangular ducts and fittings.
 - b. Single-wall round ducts and fittings.
 - c. Sheet metal materials.
 - d. Sheet metal duct liner.
 - e. Sheet metal sealants and gaskets.
 - f. Sheet metal hangers and supports.
 - 2. Flexible ducts:
 - a. Non-insulated flexible ducts.
 - b. Insulated flexible ducts.
 - 3. Air Duct Accessories:
 - a. Backdraft and pressure relief dampers.
 - b. Manual volume dampers.
 - c. Control dampers.
 - d. Fire dampers.
 - e. Flange connectors.
 - f. Turning vanes.
 - g. Duct-mounted access doors.
 - h. Flexible connectors.
 - i. Duct accessory hardware.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

B. Related Sections:

1. Section 23 05 48 "Vibration and Seismic Controls for HVAC" for vibration-isolated and restrained ductwork hangers and supports.
2. Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
3. Section 23 31 19 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Section 23 37 23 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
1. Section 28 46 21.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.
2. Section 28 46 21.13 "Conventional Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Flexible ducts.

B. Shop Drawings: For ductwork and accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top and bottom of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated, smoke-rated, and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Include plans showing locations and mounting and attachment details.
13. Hangers and supports, including methods for duct and building attachment and vibration isolation.
14. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control-damper installations.

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- d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
- e. Duct security bars.
- f. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal:

- 1. Duct material and thicknesses.
- 2. Joint and seam construction and sealing.
- 3. Reinforcement details and spacing.
- 4. Materials, fabrication, assembly, and spacing of hangers and supports.
- 5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Seismic Qualification Data: Certificates, for nonmetal ducts, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Welding certificates.
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

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1.8 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SHEET METAL DUCTS

A. PERFORMANCE REQUIREMENTS

- 1. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.
- 2. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- 3. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- 4. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- 5. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

B. SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- 1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- 2. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. For ducts with longest side less than 36-inches, select joint types in accordance with Figure 2-1.
 - b. For ducts with longest side 36-inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

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- c. Where specified for specific applications, all joints shall be welded.
- 3. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- 4. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. SINGLE-WALL ROUND DUCTS AND FITTINGS

- 1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ductmate Industries, Inc.
 - b. Elgen Manufacturing.
 - c. Linx Industries (formerly Lindab).
 - d. McGill AirFlow LLC.
 - e. MKT Metal Manufacturing.
 - f. Nordfab Ducting.
 - g. SEMCO LLC.
 - h. Set Duct Manufacturing.
 - i. Sheet Metal Connectors, Inc.
 - j. Spiral Manufacturing Co., Inc.
 - k. Stamped Fittings Inc.
- 3. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- 4. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Transverse Joints in Ducts Larger Than 60-Inches in Diameter: Flanged.
- 5. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials

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involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- a. Fabricate round ducts larger than 90-inches in diameter with butt-welded longitudinal seams.
 - b. Fabricate flat-oval ducts larger than 72-inches in width (major dimension) with butt-welded longitudinal seams.
6. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. SHEET METAL MATERIALS

1. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
2. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 - a. Galvanized Coating Designation: G90.
 - b. Finishes for Surfaces Exposed to View: Mill phosphatized.
3. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.
4. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
5. Factory- or Shop-Applied Antimicrobial Coating:
 - a. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
 - b. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - c. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested in accordance with ASTM D3363.
 - d. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
 - e. Shop-Applied Coating Color: Black or White.
 - f. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

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6. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
 - a. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
7. Tie Rods: Galvanized steel, 1/4-inch-minimum diameter for lengths 36-inches or less; 3/8-inch-minimum diameter for lengths longer than 36-inches.

E. SHEET METAL DUCT LINER

1. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) CertainTeed Corporation.
 - 2) Johns Manville; a Berkshire Hathaway company.
 - 3) Knauf Insulation.
 - 4) Owens Corning.
 - b. Maximum Thermal Conductivity:
 - 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 - 2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 - c. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - d. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.
 - 1) Adhesive shall have a VOC content of 80 g/L or less.
 - 2) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
2. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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- 1) [Aeroflex USA, Inc.](#)
 - 2) [Armacell LLC.](#)
 - 3) [Ductmate Industries, Inc.](#)
 - 4) [K-Flex USA.](#)
 - b. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
 - c. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - 1) Adhesive shall have a VOC content of 80 g/L or less.
 - 2) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
3. Fiberglass-Free Duct Liner: Made from partially recycled cotton or polyester products and containing no fiberglass. Airstream surface overlaid with fire-resistant facing to prevent surface erosion by airstream, complying with NFPA 90A or NFPA 90B. Treat natural-fiber products with antimicrobial coating.
- a. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
 - 1) [Acoustical Surfaces, Inc.](#)
 - 2) [Bonded Logic, Inc.](#)
 - 3) [Ductmate Industries, Inc.](#)
 - b. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature when tested in accordance with ASTM C518.
 - c. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with ASTM E84; certified by an NRTL.
 - d. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - 1) Adhesive shall have a VOC content of 80 g/L or less.
 - 2) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
4. Insulation Pins and Washers:
- a. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- b. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2-inches in diameter.
5. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
- a. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
 - b. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 - c. Butt transverse joints without gaps, and coat joint with adhesive.
 - d. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
 - e. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
 - f. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm or greater.
 - g. Secure liner with mechanical fasteners 4-inches from corners and at intervals not exceeding 12-inches transversely; at 3-inches from transverse joints and at intervals not exceeding 18-inches longitudinally.
 - h. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - 1) Fan discharges.
 - 2) Intervals of lined duct preceding unlined duct.
 - 3) Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
 - i. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
 - 1) Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.
 - j. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

F. SHEET METAL SEALANT AND GASKETS

- 1. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

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2. Two-Part Tape Sealing System:

- a. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
- b. Tape Width: 4-inches.
- c. Sealant: Modified styrene acrylic.
- d. Water resistant.
- e. Mold and mildew resistant.
- f. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
- g. Service: Indoor and outdoor.
- h. Service Temperature: Minus 40 to plus 200 deg F.
- i. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
- j. Sealant shall have a VOC content of 420 g/L or less.
- k. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

3. Water-Based Joint and Seam Sealant:

- a. Application Method: Brush on.
- b. Solids Content: Minimum 65 percent.
- c. Shore A Hardness: Minimum 20.
- d. Water resistant.
- e. Mold and mildew resistant.
- f. VOC: Maximum 75 g/L (less water).
- g. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
- h. Service: Indoor or outdoor.
- i. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

4. Solvent-Based Joint and Seam Sealant:

- a. Application Method: Brush on.
- b. Base: Synthetic rubber resin.
- c. Solvent: Toluene and heptane.
- d. Solids Content: Minimum 60 percent.
- e. Shore A Hardness: Minimum 60.
- f. Water resistant.
- g. Mold and mildew resistant.
- h. Sealant shall have a VOC content of 420 g/L or less.
- i. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- j. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
- k. Service: Indoor or outdoor.
- l. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

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5. Flanged Joint Sealant: Comply with ASTM C920.
 - a. General: Single-component, acid-curing, silicone, elastomeric.
 - b. Type: S.
 - c. Grade: NS.
 - d. Class: 25.
 - e. Use: O.
 - f. Sealant shall have a VOC content of 420 g/L or less.
 - g. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
6. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
7. Round Duct Joint O-Ring Seals:
 - a. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
 - b. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 - c. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

G. SHEET METAL HANGERS AND SUPPORTS

1. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.
2. Hanger Rods for Corrosive Environments: Electroplated, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
3. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
4. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
5. Trapeze and Riser Supports:
 - a. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - b. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - c. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.2 FLEXIBLE DUCTS

A. INSULATED FLEXIBLE DUCTS

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexmaster U.S.A., Inc.
 - b. JP Lamborn Co.
 - c. McGill AirFlow LLC.
 - d. Thermaflex; a Flex-Tek Group company.
 - e. Ward Industries; a brand of Hart & Cooley, Inc.
2. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
 - a. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 - b. Maximum Air Velocity: 4000 fpm.
 - c. Temperature Range: Minus 10 to plus 160 deg F.
 - d. Insulation R-Value: R6.

B. FLEXIBLE DUCT CONNECTORS

1. Clamps: Nylon strap in sizes 3 through 18-inches, to suit duct size.

2.3 AIR DUCT ACCESSORIES

A. ASSEMBLY DESCRIPTION

1. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
2. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. MATERIALS

1. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 - a. Galvanized Coating Designation: G90.
 - b. Exposed-Surface Finish: Mill phosphatized.
2. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.
3. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
4. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.

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5. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
6. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36-inches or less; 3/8-inch minimum diameter for lengths longer than 36-inches.

C. BACKDRAFT AND PRESSURE RELIEF DAMPERS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Warming and Ventilating; a Mestek Architectural Group company.
 - b. Cesco Products; a division of MESTEK, Inc.
 - c. Flex-Tek Group.
 - d. Greenheck Fan Corporation.
 - e. Lloyd Industries, Inc.
 - f. Nailor Industries Inc.
 - g. NCA Manufacturing, Inc.
 - h. Pottorff.
 - i. Ruskin Company.
 - j. Safe Air - Dowco Products.
 - k. United Enertech.
 - l. Vent Products Co., Inc.
2. Description: Gravity balanced.
3. Maximum Air Velocity: 2000 fpm.
4. Maximum System Pressure: 2-inch wg.
5. Frame: Hat-shaped, 0.05-inch-thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.
6. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum with sealed edges.
7. Blade Action: Parallel.
8. Blade Seals: Extruded vinyl, mechanically locked.
9. Blade Axles:
 - a. Material: Galvanized steel.
 - b. Diameter: 0.20-inch.
10. Tie Bars and Brackets: Galvanized steel.
11. Return Spring: Adjustable tension.
12. Bearings: Steel ball or synthetic pivot bushings.

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13. Accessories:

- a. Adjustment device to permit setting for varying differential static pressure.
- b. Counterweights and spring-assist kits for vertical airflow installations.
- c. Electric actuators.
- d. Chain pulls.
- e. Screen Mounting: Front mounted in sleeve.
 - 1) Sleeve Thickness: 20 gage minimum.
 - 2) Sleeve Length: 6-inches minimum.
- f. Screen Mounting: Rear mounted.
- g. Screen Material: Aluminum.
- h. Screen Type: Bird.
- i. 90-degree stops.

D. MANUAL VOLUME DAMPERS

1. Standard, Steel, Manual Volume Dampers:

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Aire Technologies.
 - 2) American Warming and Ventilating; a Mestek Architectural Group company.
 - 3) Flexmaster U.S.A., Inc.
 - 4) Flex-Tek Group.
 - 5) McGill AirFlow LLC.
 - 6) Nailor Industries Inc.
 - 7) Pottorff.
 - 8) Ruskin Company.
 - 9) Safe Air - Dowco Products.
 - 10) Trox USA Inc.
 - 11) United Enertech.
 - 12) Vent Products Co., Inc.
- b. Standard leakage rating.
- c. Suitable for horizontal or vertical applications.
- d. Frames:
 - 1) Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel.
 - 2) Mitered and welded corners.
 - 3) Flanges for attaching to walls and flangeless frames for installing in ducts.
- e. Blades:
 - 1) Multiple or single blade.
 - 2) Parallel- or opposed-blade design.
 - 3) Stiffen damper blades for stability.

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- 4) Galvanized-steel, 0.064-inch thick.
 - f. Blade Axles: Galvanized steel.
 - g. Bearings:
 - 1) Molded synthetic.
 - 2) Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - h. Tie Bars and Brackets: Galvanized steel.
2. Standard, Aluminum, Manual Volume Dampers:
- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) American Warming and Ventilating; a Mestek Architectural Group company.
 - 2) McGill AirFlow LLC.
 - 3) Nailor Industries Inc.
 - 4) Pottorff.
 - 5) Ruskin Company.
 - 6) Safe Air - Dowco Products.
 - 7) Trox USA Inc.
 - 8) United Enertech.
 - 9) Vent Products Co., Inc.
 - b. Standard leakage rating.
 - c. Suitable for horizontal or vertical applications.
 - d. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
 - e. Blades:
 - 1) Multiple or single blade.
 - 2) Parallel- or opposed-blade design.
 - 3) Stiffen damper blades for stability.
 - 4) Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
 - 5) Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.
 - f. Blade Axles: Nonferrous metal.
 - g. Bearings:
 - 1) Molded synthetic.
 - 2) Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - h. Tie Bars and Brackets: Aluminum.
3. Jackshaft:
- a. Size: 1-inch diameter.

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- b. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 - c. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
4. Damper Hardware:
- a. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
 - b. Include center hole to suit damper operating-rod size.
 - c. Include elevated platform for insulated duct mounting.

E. CONTROL DAMPERS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Warming and Ventilating; a Mestek Architectural Group company.
 - b. Arrow United Industries.
 - c. Cesco Products; a division of MESTEK, Inc.
 - d. Flex-Tek Group.
 - e. Greenheck Fan Corporation.
 - f. Lloyd Industries, Inc.
 - g. McGill AirFlow LLC.
 - h. Metal Form Manufacturing, Inc.
 - i. Nailor Industries Inc.
 - j. NCA Manufacturing, Inc.
 - k. Pottorff.
 - l. Ruskin Company.
 - m. Safe Air - Dowco Products.
 - n. United Enertech.
 - o. Vent Products Co., Inc.
 - p. Young Regulator Company.
2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
3. Frames:
 - a. U shaped.
 - b. 0.094-inch-thick, galvanized sheet steel.
 - c. Mitered and welded corners.
4. Blades:
 - a. Multiple blade with maximum blade width of 8-inches.
 - b. Parallel- and opposed-blade design.
 - c. Galvanized-steel.
 - d. 0.064-inch thick single skin.
 - e. Blade Edging: Closed-cell neoprene.

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- f. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- 5. Blade Axles: 1/2-inch-diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
 - a. Operating Temperature Range: From minus 40 to plus 200 deg F.
- 6. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - c. Thrust bearings at each end of every blade.

F. FIRE DAMPERS

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance; a division of MESTEK, Inc.
 - b. Aire Technologies.
 - c. American Warming and Ventilating; a Mestek Architectural Group company.
 - d. Arrow United Industries.
 - e. Cesco Products; a division of MESTEK, Inc.
 - f. Greenheck Fan Corporation.
 - g. Nailor Industries Inc.
 - h. NCA Manufacturing, Inc.
 - i. Pottorff.
 - j. Prefco.
 - k. Ruskin Company.
 - l. Safe Air - Dowco Products.
 - m. United Enertech.
 - n. Vent Products Co., Inc.
 - o. Ward Industries; a brand of Hart & Cooley, Inc.
- 2. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- 3. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- 4. Fire Rating: 1-1/2 and 3 hours.
- 5. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.
- 6. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 - a. Minimum Thickness: 0.05 thick, as indicated, and of length to suit application.

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- b. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- 7. Mounting Orientation: Vertical or horizontal as indicated.
- 8. Blades: Roll-formed, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
- 9. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- 10. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.
- 11. Heat-Responsive Device: Electric, resettable link and switch package, factory installed, 165 deg F rated.

G. FLANGE CONNECTORS

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CL WARD & Family Inc.
 - b. Ductmate Industries, Inc.
 - c. Elgen Manufacturing.
 - d. Hardcast, Inc.
 - e. Nexus PDQ.
 - f. Ward Industries; a brand of Hart & Cooley, Inc.
- 2. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- 3. Material: Galvanized steel.
- 4. Gage and Shape: Match connecting ductwork.

H. TURNING VANES

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aero-Dyne Sound Control Co.
 - b. CL WARD & Family Inc.
 - c. Ductmate Industries, Inc.
 - d. Duro Dyne Inc.
 - e. Elgen Manufacturing.
 - f. Hardcast, Inc.
 - g. METALAIRE, Inc.
 - h. SEMCO LLC.
 - i. Ward Industries; a brand of Hart & Cooley, Inc.

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2. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - a. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
3. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
4. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
5. Vane Construction: Double wall.
6. Vane Construction: Single wall for ducts up to 48-inches wide and double wall for larger dimensions.

I. DUCT-MOUNTED ACCESS DOORS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aire Technologies.
 - b. American Warming and Ventilating; a Mestek Architectural Group company.
 - c. Cesco Products; a division of MESTEK, Inc.
 - d. CL WARD & Family Inc.
 - e. Ductmate Industries, Inc.
 - f. Elgen Manufacturing.
 - g. Flexmaster U.S.A., Inc.
 - h. Greenheck Fan Corporation.
 - i. McGill AirFlow LLC.
 - j. Nailor Industries Inc.
 - k. Pottorff.
 - l. United Enertech.
 - m. Ventfabrics, Inc.
 - n. Ward Industries; a brand of Hart & Cooley, Inc.
2. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
 - a. Door:
 - 1) Double wall, rectangular.
 - 2) Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - 3) Vision panel.
 - 4) Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.

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- 5) Fabricate doors airtight and suitable for duct pressure class.
- b. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
- c. Number of Hinges and Locks:
 - 1) Access Doors Less Than 12-inches Square: No hinges and two sash locks.
 - 2) Access Doors up to 18-inches Square: Two hinges and two sash locks.
 - 3) Access Doors up to 24 by 48-inches: Three hinges and two compression latches with outside and inside handles.
 - 4) Access Doors Larger Than 24 by 48-inches: Four hinges and two compression latches with outside and inside handles.
- 3. Pressure Relief Access Door:
 - a. Door and Frame Material: Galvanized sheet steel.
 - b. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
 - c. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
 - d. Factory set at 10-inch wg.
 - e. Doors close when pressures are within set-point range.
 - f. Hinge: Continuous piano.
 - g. Latches: Cam.
 - h. Seal: Neoprene or foam rubber.
 - i. Insulation Fill: 1-inch-thick, fibrous-glass or polystyrene-foam board.

J. DUCT ACCESS PANEL ASSEMBLIES

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M.
 - b. CL WARD & Family Inc.
 - c. Ductmate Industries, Inc.
 - d. Flame Gard, Inc.
- 2. Labeled according to UL 1978 by an NRTL.
- 3. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.
- 4. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
- 5. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.
- 6. Minimum Pressure Rating: 10-inch wg, positive or negative.

K. FLEXIBLE CONNECTORS

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CL WARD & Family Inc.
 - b. Ductmate Industries, Inc.
 - c. Duro Dyne Inc.
 - d. Elgen Manufacturing.
 - e. Hardcast, Inc.
 - f. JP Lamborn Co.
 - g. Ventfabrics, Inc.
 - h. Ward Industries; a brand of Hart & Cooley, Inc.
2. Materials: Flame-retardant or noncombustible fabrics.
3. Coatings and Adhesives: Comply with UL 181, Class 1.
4. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2-inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
5. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - a. Minimum Weight: 26 oz./sq. yd..
 - b. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - c. Service Temperature: Minus 40 to plus 200 deg F.
6. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - a. Minimum Weight: 24 oz./sq. yd..
 - b. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 - c. Service Temperature: Minus 50 to plus 250 deg F.
7. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - a. Minimum Weight: 16 oz./sq. yd..
 - b. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
 - c. Service Temperature: Minus 67 to plus 500 deg F.
8. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
 - a. Minimum Weight: 14 oz./sq. yd..
 - b. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
 - c. Service Temperature: Minus 67 to plus 500 deg F.
9. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

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- a. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
- b. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
- c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
- d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
- g. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

L. DUCT ACCESSORY HARDWARE

1. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
2. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 SHEET METAL DUCTS

A. DUCT INSTALLATION

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.
2. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
3. Install ducts in maximum practical lengths with fewest possible joints.
4. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
5. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
6. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

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7. Install ducts with a clearance of 1-inch, plus allowance for insulation thickness.
8. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
9. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2-inches.
10. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements for fire and smoke dampers and specific installation requirements of the damper UL listing.
11. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
12. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."
13. Elbows: Use long-radius elbows wherever they fit.
 - a. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 - b. Fabricate 90-degree round elbows with a minimum of three segments for 12-inches and smaller and a minimum of five segments for 14-inches and larger.
14. Branch Connections: Use lateral or conical branch connections.

B. INSTALLATION OF EXPOSED DUCTWORK

1. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
2. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
3. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
4. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
5. Repair or replace damaged sections and finished work that does not comply with these requirements.

C. ADDITIONAL INSTALLATION REQUIREMENTS FOR EXHAUST DUCTS SERVING COMMERCIAL DISHWASHERS AND OTHER HIGH-HUMIDITY LOCATIONS

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Install dishwasher exhaust ducts and other exhaust ducts from wet, high-humidity locations without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to dishwasher or toward drain.
2. Provide a drain pocket at each low point and at the base of each riser with a 1-inch trapped copper drain from each drain pocket to open site floor drain.
3. Minimize number of transverse seams.
4. Do not locate longitudinal seams on bottom of duct.

D. DUCT SEALING

1. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. HANGER AND SUPPORT INSTALLATION

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
2. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - a. Where practical, install concrete inserts before placing concrete.
 - b. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - c. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4-inches thick.
 - d. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4-inches thick.
 - e. Do not use powder-actuated concrete fasteners for seismic restraints.
3. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24-inches of each elbow and within 48-inches of each branch intersection.
4. Hangers Exposed to View: Threaded rod and angle or channel supports.
5. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
6. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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F. CONNECTIONS

1. Make connections to equipment with flexible connectors complying with the "Air Duct Accessories" section of this specification.
2. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

G. PAINTING

1. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 09 91 13 "Exterior Painting" and Section 09 91 23 "Interior Painting."

H. FIELD QUALITY CONTROL

1. Perform tests and inspections.
2. Leakage Tests:
 - a. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - b. Test the following systems:
 - 1) Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, selected by Architect/Engineer from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - 2) Supply Ducts with a Pressure Class of 4-Inch wg or Higher: Test representative duct sections, selected by Architect/Engineer from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - 3) Return Ducts with a Pressure Class of 3-Inch wg or Higher: Test representative duct sections, selected by Architect/Engineer from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - 4) Exhaust Ducts with a Pressure Class of 4-Inch wg or Higher: Test representative duct sections, selected by Architect/Engineer from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - 5) Outdoor-Air Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect/Engineer from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
 - c. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

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- d. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
 - e. Test for leaks before applying external insulation.
 - f. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - g. Give seven days' advance notice for testing.
3. Duct System Cleanliness Tests:
- a. Visually inspect duct system to ensure that no visible contaminants are present.
 - b. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - 1) Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
4. Duct system will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

I. DUCT CLEANING

- 1. Clean new duct system(s) before testing, adjusting, and balancing.
- 2. For cleaning of existing ductwork, see Section 23 01 30.52 "Existing HVAC Air Distribution System Cleaning."
- 3. Use duct cleaning methodology as indicated in NADCA ACR.
- 4. Use service openings for entry and inspection.
 - a. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 23 33 00 "Air Duct Accessories" for access panels and doors.
 - b. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - c. Remove and reinstall ceiling to gain access during the cleaning process.
- 5. Particulate Collection and Odor Control:
 - a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - b. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

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6. Clean the following components by removing surface contaminants and deposits:
 - a. Air outlets and inlets (registers, grilles, and diffusers).
 - b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - d. Coils and related components.
 - e. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - f. Supply-air ducts, dampers, actuators, and turning vanes.
 - g. Dedicated exhaust and ventilation components and makeup air systems.
7. Mechanical Cleaning Methodology:
 - a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - b. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - d. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 - e. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 - f. Provide drainage and cleanup for wash-down procedures.
 - g. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

J. STARTUP

1. Air Balance: Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC."

K. DUCT SCHEDULE

1. Fabricate ducts as indicated in the following schedules and notes.
 - a. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.
 - b. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Supply Ducts:

System/ Equipment	Duct Material	Pressure Class (inch wg)	Minimum SMACNA Seal Class	SMACNA Leakage Class		Notes
				Rectangular	Round/Flat Oval	
<u>Low Pressure:</u> - Air-Handling Units - Fan Coil Units - Furnaces - Heat Pumps - Terminal Units	G-90 Galvanized Sheet Steel	(+) ≤ 2	B	6	3	1
<u>Medium Pressure:</u> - Air-Handling Units	G-90 Galvanized Sheet Steel	(+) ≥ 2 and ≤ 4	A	6	3	1
<u>High Pressure:</u> - Air-Handling Units	G-90 Galvanized Sheet Steel	(+) ≥ 4	A	3	3	1
Legend: (+) – Positive Pressure (-) – Negative Pressure (+/-) – Positive or Negative Pressure Notes: 1. Unless noted otherwise, ductwork installed in exposed locations shall be provided with a mill finish and without shop stickers.						

3. Return and Outdoor Ducts:

System/ Equipment	Duct Material	Pressure Class (inch wg)	Minimum SMACNA Seal Class	SMACNA Leakage Class		Notes
				Rectangular	Round/Flat Oval	
<u>Low Pressure:</u> - Air-Handling Units - Fan Coil Units - Furnaces - Heat Pumps - Terminal Units	G-90 Galvanized Sheet Steel	(+/-) ≤ 2	B	12	12	1
<u>Medium Pressure:</u> - Air-Handling Units	G-90 Galvanized Sheet Steel	(+/-) > 2	B	6	6	1
Legend: (+) – Positive Pressure (-) – Negative Pressure (+/-) – Positive or Negative Pressure Notes: 1. Unless noted otherwise, ductwork installed in exposed locations shall be provided with a mill finish and without shop stickers.						

4. Exhaust Ducts:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

System/ Equipment	Duct Material	Pressure Class (inch wg)	Minimum SMACNA Seal Class	SMACNA Leakage Class		Notes
				Rectangular	Round/Flat Oval	
<u>Low Pressure:</u> - Class 1 and 2 Air (ASHRAE 62.1)	G-90 Galvanized Sheet Steel	(+/-) ≤ 2	(-): B (+): A	12	6	1
<u>Low Pressure:</u> - Air-Handling Units	G-90 Galvanized Sheet Steel	(+/-) ≤ 2	(-): B (+): A	24	12	1
<u>Medium Pressure:</u> - Air-Handling Units	G-90 Galvanized Sheet Steel	(+/-) ≥ 2 and ≤ 4	B	6	6	1
Commercial Kitchen Hoods (Comply with NFPA 96)	Exposed: Type 304, Stainless Sheet Steel, No. 4 finish Concealed: Carbon- steel Sheet	(+/-) ≤ 2	Welded seams and joints. Air and water tight.	3	3	1
Dishwasher Hoods High-Humidity Locations	Exposed: Type 304, Stainless Sheet Steel, No. 4 finish Concealed: Aluminum Sheet, Mill finish	(+/-) ≤ 2	Welded seams and flanged joints with watertight EPDM gaskets.	3	3	1
Class 3 and 4 Air (ASHRAE 62.1) Fume Hoods Laboratory Air Process Air	Exposed: Type 316, Stainless Sheet Steel, No. 4 finish Concealed: Type 316, Stainless Sheet Steel, No. 2B finish PVC-coated, galvanized sheet steel with thicker coating on duct interior.	(+/-) ≤ 4	Welded seams and joints. Air and water tight.	3	3	1
Legend: (+) – Positive Pressure (-) – Negative Pressure (+/-) – Positive or Negative Pressure Notes: 1. Unless otherwise noted, ductwork installed in exposed locations shall be provided with a mill finish and without shop stickers.						

5. Intermediate Reinforcement:

- a. Galvanized-Steel Ducts: Galvanized steel.
- b. Stainless-Steel Ducts:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- 1) Exposed to Airstream: Match duct material.
- 2) Not Exposed to Airstream: Match duct material.

c. Aluminum Ducts: Aluminum.

6. Liner:

System	Location	Liner Material	Thickness (in.)	R-Value h x sq. ft. x deg F/Btu	Notes
<u>Supply Air Ducts - Low Pressure:</u> - Air-Handling Units - Fan Coil Units - Furnaces - Heat Pumps - Terminal Units	First 10 ft. downstream of equipment outlet.	Fibrous glass, Type I	1-1/2	6.0	1, 2
<u>Supply Air Ducts - Medium Pressure:</u> - Air-Handling Units	First 20 ft. downstream of equipment outlet.	Fibrous glass, Type I	1-1/2	6.0	1, 2
<u>Return Air Ducts - Low Pressure:</u> - Air-Handling Units - Fan Coil Units - Furnaces - Heat Pumps - Terminal Units	First 10 ft. downstream of equipment outlet.	Fibrous glass, Type I	1-1/2	6.0	1, 2
<u>Return Air Ducts - Medium Pressure:</u> - Air-Handling Units	First 20 ft. downstream of equipment outlet.	Fibrous glass, Type I	1-1/2	6.0	1, 2
Transfer Air Ducts	Lined throughout entire length of duct.	Fibrous glass, Type I	1-1/2	6.0	1, 2
Noted on Plans	As shown on plans.	Fibrous glass, Type I	1-1/2	6.0	1, 2
Notes: 1. Lined ductwork does not require external insulation if the R-value of the internal duct liner meets the required installed R-value noted in the duct insulation specifications and the applicable version of the International Energy Conservation Code (IECC). 2. All ductwork dimensions shown on the plans are the clear inside dimensions. All lined ductwork will require an increase in overall size to accommodate lining and maintain clear inside dimensions shown on plans.					

7. Elbow Configuration:

a. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

- 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - b. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - 1) Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - a) Radius-to Diameter Ratio: 1.5.
8. Branch Configuration:
- a. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - 1) Rectangular Main to Rectangular Branch: 45-degree entry.
 - 2) Rectangular Main to Round Branch: Conical spin in.
 - b. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - 1) Velocity 1000 fpm or Lower: 90-degree tap.
 - 2) Velocity 1000 to 1500 fpm: Conical tap.
 - 3) Velocity 1500 fpm or Higher: 45-degree lateral.

3.2 FLEXIBLE DUCTS

A. INSTALLATION

1. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
2. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.
3. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.
4. Connect flexible ducts to metal ducts with draw bands.
5. Install duct test holes where required for testing and balancing purposes.
6. Installation:

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- a. Install ducts fully extended.
- b. Do not bend ducts across sharp corners.
- c. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
- d. Avoid contact with metal fixtures, water lines, pipes, or conduits.
- e. Install flexible ducts in a direct line, without sags, twists, or turns.

7. Supporting Flexible Ducts:

- a. Suspend flexible ducts with bands 1-1/2-inches wide or wider and spaced a maximum of 48-inches apart. Maximum centerline sag between supports shall not exceed 1/2-inch per 12-inches.
- b. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
- c. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
- d. Vertically installed ducts shall be stabilized by support straps at a maximum of 72-inches o.c.

3.3 AIR DUCT ACCESSORIES

A. INSTALLATION

1. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
2. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
3. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
4. Install volume dampers at points on supply, return, and exhaust systems at all branches. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - a. Install steel volume dampers in steel ducts.
 - b. Install aluminum volume dampers in aluminum ducts.
5. Set dampers to fully open position before testing, adjusting, and balancing.
6. Install test holes at fan inlets and outlets and elsewhere as indicated.
7. Install fire dampers according to UL listing.

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8. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - a. On both sides of duct coils.
 - b. Upstream from duct filters.
 - c. At outdoor-air intakes and mixed-air plenums.
 - d. At drain pans and seals.
 - e. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - f. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - g. At each change in direction and at maximum 50-foot spacing.
 - h. Upstream from turning vanes.
 - i. Upstream or downstream from duct silencers.
 - j. Control devices requiring inspection.
 - k. Elsewhere as indicated.
9. Install access doors with swing against duct static pressure.
10. Access Door Sizes:
 - a. One-Hand or Inspection Access: 8 by 5-inches.
 - b. Two-Hand Access: 12 by 6-inches.
 - c. Head and Hand Access: 18 by 10-inches.
 - d. Head and Shoulders Access: 21 by 14-inches.
 - e. Body Access: 25 by 14-inches.
 - f. Body plus Ladder Access: 25 by 17-inches.
11. Label access doors according to Section 23 05 53 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
12. Install flexible connectors to connect ducts to equipment.
13. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
14. Install duct test holes where required for testing and balancing purposes.
15. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

B. FIELD QUALITY CONTROL

1. Tests and Inspections:
 - a. Operate dampers to verify full range of movement.

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- b. Inspect locations of access doors and verify that purpose of access door can be performed.
- c. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
- d. Inspect turning vanes for proper and secure installation.
- e. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

SECTION 23 34 23

HVAC POWER VENTILATORS
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 010)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY:

- A. Section Includes:
 - 1. Utility set fans.
 - 2. Centrifugal roof ventilators.
 - 3. Axial roof ventilators.
 - 4. Upblast propeller roof exhaust fans.
 - 5. Centrifugal wall ventilators.
 - 6. Ceiling-mounted ventilators.
 - 7. In-line centrifugal fans.
 - 8. Propeller fans.
 - 9. Hi Volume Low Speed Fans

1.4 PERFORMANCE REQUIREMENTS:

- A. Project Altitude: Base fan-performance ratings on [**actual Project site elevations**] [**sea level**].
- B. Operating Limits: Classify according to AMCA 99.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1.5 ACTION SUBMITTALS:

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Roof curbs.
 - 7. Fan speed controllers.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 2. Design Calculations: Calculate requirements for selecting vibration isolators [**and seismic restraints**] and for designing vibration isolation bases.

1.6 INFORMATIONAL SUBMITTALS:

- A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - 1. Roof framing and support members relative to duct penetrations.
 - 2. Ceiling suspension assembly members.
 - 3. Size and location of initial access modules for acoustical tile.
 - 4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- B. Field quality-control reports.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1.7 CLOSEOUT SUBMITTALS:

- A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS:

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Belts: [**One**] <**Insert number**> set(s) for each belt-driven unit.

1.9 QUALITY ASSURANCE:

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.
- C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.10 COORDINATION:

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.
- C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 UTILITY SET FANS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Housing: Fabricated of [**galvanized**] steel with side sheets fastened with a deep lock seam or welded to scroll sheets.
 - 1. Housing Discharge Arrangement: Adjustable to eight standard positions.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- C. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.
 - 1. Blade Materials: **[Steel]** **[Aluminum]**.
 - 2. Blade Type: **[Backward inclined]** **[Forward curved]** **[Airfoil]**.
 - 3. Spark-Resistant Construction: AMCA 99, Type **[A]** **[B]** **[C]**.
- D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
- E. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, **[L₅₀ of 200,000 hours]** **[L₁₀ of 80,000 hours]** **<Insert life>**.
 - 1. Extend grease fitting to accessible location outside of unit.
- F. Belt Drives:
 - 1. Factory mounted, with final alignment and belt adjustment made after installation
 - 2. Service Factor Based on Fan Motor Size: **[1.5]** **[1.4]** **[1.3]** **[1.2]**.
 - 3. Motor Pulleys: Adjustable pitch for use with motors through **[5]** **<Insert value>** hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - 4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - 5. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
- G. Accessories:
 - 1. Inlet and Outlet: Flanged.
 - 2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
 - 3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades with felt edges in steel frame installed on fan discharge.
 - 4. Access Door: Gasketed door in scroll with latch-type handles.
 - 5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
 - 6. Inlet Screens: Removable wire mesh.
 - 7. Drain Connections: NPS 3/4 threaded coupling drain connection installed at lowest point of housing.
 - 8. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
 - 9. Discharge Dampers: Assembly with **[parallel]** **[opposed]** blades constructed of two plates formed around and to shaft, channel frame, sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
 - 10. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

11. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

H. Capacities and Characteristics:

1. Airflow: **<Insert cfm>**.
2. External Static Pressure: **<Insert inches wg>**.
3. Fan Diameter: **<Insert inches>**.
4. Wheel Type: **[Backward inclined] [Forward curved] [Airfoil]**.
5. Class: **[I] [II] [III]**.
6. Drive Arrangement: **[Direct] [Belt]**.
7. Fan rpm: **<Insert value>**.
8. Outlet Velocity: **<Insert fpm>**.
9. Brake Horsepower: **<Insert value>**.
10. Motor Size: **<Insert value>** hp.
11. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
12. Vibration Isolators:
 - a. Type: **[Spring isolators] [Restrained spring isolators] <Insert type>**.
 - b. Static Deflection: **<Insert inches>**.
13. Spark Arrestance Class: **[A] [B] [C]**.

2.2 CENTRIFUGAL ROOF VENTILATORS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Housing: Removable, **[spun-aluminum, dome top and outlet baffle] [extruded-aluminum, rectangular top] [galvanized steel, mushroom-domed top]**; square, one-piece, aluminum base with venturi inlet cone.
 1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains **[and grease collector]**.
 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- D. Belt Drives:
 1. Resiliently mounted to housing.
 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted **[inside]** **[outside]** fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: **[Self-flashing without a cant strip, with mounting flange]** **[Built-in cant and mounting flange]** **[Built-in raised cant and mounting flange]**.
2. Overall Height: **[8 inches]** **[9-1/2 inches]** **[12 inches]** **[16 inches]** **[18 inches]**.
3. Sound Curb: Curb with sound-absorbing insulation.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Burglar Bars: **[1/2-inch-]** **[5/8-inch-]** **[3/4-inch-]** thick steel bars welded in place to form 6-inch squares.
7. Mounting Pedestal: Galvanized steel with removable access panel.
8. Vented Curb: Unlined with louvered vents in vertical sides.

G. Capacities and Characteristics:

1. Airflow: **<Insert cfm>**.
2. External Static Pressure: **<Insert inches wg>**.
3. Fan Diameter: **<Insert inches>**.
4. Drive Arrangement: **[Direct]** **[Belt drive]**.
5. Fan rpm: **<Insert value>**.
6. Tip Speed: **<Insert fpm>**.
7. Sound: **<Insert sone>**.
8. Curb Size: **<Insert inches by inches>**.
9. Curb Height: **<Insert inches>**.
10. Damper: **[Yes]** **[No]**.
11. Damper Size: **<Insert inches by inches>**.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

12. Brake Horsepower: **<Insert value>**.
13. Motor Size: **<Insert value>** hp.
14. Motor rpm: **<Insert value>**.
15. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.

2.3 AXIAL ROOF VENTILATORS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base.
 1. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- C. Fan Wheel: [**Aluminum**] [**Steel**] hub and blades.
- D. Belt Drives:
 1. Resiliently mounted to housing.
 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
- E. Accessories:
 1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted [**inside**] [**outside**] fan housing, factory wired through an internal aluminum conduit.
 2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
 3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
 4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
- F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
 1. Configuration: [**Self-flashing without a cant strip, with mounting flange**] [**Built-in cant and mounting flange**] [**Built-in raised cant and mounting flange**].

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Overall Height: [**8 inches**] [**9-1/2 inches**] [**12 inches**] [**16 inches**] [**18 inches**].
3. Sound Curb: Curb with sound-absorbing insulation.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Burglar Bars: [**1/2-inch-**] [**5/8-inch-**] [**3/4-inch-**] thick steel bars welded in place to form 6-inch squares.
7. Mounting Pedestal: Galvanized steel with removable access panel.

G. Capacities and Characteristics:

1. Airflow: <**Insert cfm**>.
2. External Static Pressure: <**Insert inches wg**>.
3. Fan Diameter: <**Insert inches**>.
4. Drive Arrangement: [**Direct**] [**Belt drive**].
5. Fan rpm: <**Insert value**>.
6. Tip Speed: <**Insert fpm**>.
7. Sound: <**Insert sone**>.
8. Curb Size: <**Insert inches by inches**>.
9. Curb Height: <**Insert inches**>.
10. Damper: [**Yes**] [**No**].
11. Damper Size: <**Insert inches by inches**>.
12. Brake Horsepower: <**Insert value**>.
13. Motor Size: <**Insert value**> hp.
14. Motor rpm: <**Insert value**>.
15. Electrical Characteristics:
 - a. Volts: <**Insert value**>.
 - b. Phase: <**Insert value**>.
 - c. Hertz: <**Insert value**>.

2.4 UPBLAST PROPELLER ROOF EXHAUST FANS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Wind Band, Fan Housing, and Base: Reinforced and braced [**galvanized steel**] [**aluminum**], containing [**galvanized-steel**] [**aluminum**] butterfly dampers and rain trough, motor and drive assembly, and fan wheel.
 1. Damper Rods: Steel with [**bronze**] [**nylon**] bearings.
 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- C. Fan Wheel: Replaceable, [**cast**] [**extruded**]-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
- D. Belt Drives:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Resiliently mounted to housing.
 2. Weatherproof housing of same material as fan housing.
 3. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 4. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
 5. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 6. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.
- E. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
1. Configuration: [**Self-flashing without a cant strip, with mounting flange**] [**Built-in cant and mounting flange**] [**Built-in raised cant and mounting flange**].
 2. Overall Height: [**8 inches**] [**9-1/2 inches**] [**12 inches**] [**16 inches**] [**18 inches**].
 3. Sound Curb: Curb with sound-absorbing insulation.
 4. Pitch Mounting: Manufacture curb for roof slope.
 5. Metal Liner: Galvanized steel.
 6. Burglar Bars: [**1/2-inch-**] [**5/8-inch-**] [**3/4-inch-**] thick steel bars welded in place to form 6-inch squares.
 7. Mounting Pedestal: Galvanized steel with removable access panel.
- F. Capacities and Characteristics:
1. Airflow: <**Insert cfm**>.
 2. External Static Pressure: <**Insert inches wg**>.
 3. Fan Diameter: <**Insert inches**>.
 4. Drive Arrangement: [**Direct**] [**Belt drive**].
 5. Fan rpm: <**Insert value**>.
 6. Tip Speed: <**Insert fpm**>.
 7. Sound: <**Insert sone**>.
 8. Curb Size: <**Insert inches by inches**>.
 9. Curb Height: <**Insert inches**>.
 10. Damper: [**Yes**] [**No**].
 11. Damper Size: <**Insert inches by inches**>.
 12. Brake Horsepower: <**Insert value**>.
 13. Motor Size: <**Insert value**> hp.
 14. Motor rpm: <**Insert value**>.
 15. Electrical Characteristics:
 - a. Volts: <**Insert value**>.
 - b. Phase: <**Insert value**>.
 - c. Hertz: <**Insert value**>.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.5 CENTRIFUGAL WALL VENTILATORS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.
- C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.
- D. Belt Drives:
 - 1. Resiliently mounted to housing.
 - 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 - 5. Fan and motor isolated from exhaust airstream.
- E. Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
 - 3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
 - 4. Wall Grille: Ring type for flush mounting.
 - 5. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
 - 6. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
- F. Capacities and Characteristics:
 - 1. Airflow: **<Insert cfm>**.
 - 2. External Static Pressure: **<Insert inches wg>**.
 - 3. Fan Diameter: **<Insert inches>**.
 - 4. Drive Arrangement: **[Direct] [Belt drive]**.
 - 5. Fan rpm: **<Insert value>**.
 - 6. Tip Speed: **<Insert fpm>**.
 - 7. Sound: **<Insert sone>**.
 - 8. Damper: **[Yes] [No]**.
 - 9. Damper Size: **<Insert inches by inches>**.
 - 10. Brake Horsepower: **<Insert value>**.
 - 11. Motor Size: **<Insert value> hp**.
 - 12. Motor rpm: **<Insert value>**.
 - 13. Electrical Characteristics:
 - a. Volts: **<Insert value>**.

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- b. Phase: **<Insert value>**.
- c. Hertz: **<Insert value>**.

2.6 CEILING-MOUNTED VENTILATORS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Housing: Steel, lined with acoustical insulation.
- C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
- D. Grille: [**Plastic**] [**Stainless steel**] [**Aluminum**] [**Painted aluminum**], louvered grille with flange on intake and thumbscrew attachment to fan housing.
- E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
- F. Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
 - 3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
 - 4. Motion Sensor: Motion detector with adjustable shutoff timer.
 - 5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
 - 6. Filter: Washable aluminum to fit between fan and grille.
 - 7. Isolation: Rubber-in-shear vibration isolators.
 - 8. Manufacturer's standard roof jack or wall cap, and transition fittings.
- G. Capacities and Characteristics:
 - 1. Airflow: **<Insert cfm>**.
 - 2. External Static Pressure: **<Insert inches wg>**.
 - 3. Sound: **<Insert sone>**.
 - 4. Motor Size: **<Insert value>** hp.
 - 5. Motor rpm: **<Insert value>**.
 - 6. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.

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2.7 IN-LINE CENTRIFUGAL FANS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing [**; with wheel, inlet cone, and motor on swing-out service door**].
- D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- F. Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 - 3. Companion Flanges: For inlet and outlet duct connections.
 - 4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 - 5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
- G. Capacities and Characteristics:
 - 1. Airflow: **<Insert cfm>**.
 - 2. External Static Pressure: **<Insert inches wg>**.
 - 3. Fan Diameter: **<Insert inches>**.
 - 4. Wheel Type: [**Backward inclined**] [**Forward curved**] [**Airfoil**].
 - 5. Class: [**I**] [**II**] [**III**].
 - 6. Drive Arrangement: **<Insert AMCA number>**.
 - 7. Fan rpm: **<Insert value>**.
 - 8. Outlet Velocity: **<Insert fpm>**.
 - 9. Brake Horsepower: **<Insert value>**.
 - 10. Motor Size: **<Insert value>** hp.
 - 11. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
 - 12. Vibration Isolators:

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- a. Type: [Elastomeric hangers] <Insert type>.
- b. Static Deflection: [1 inch] <Insert value>.

13. Spark Arrestance Class: [A] [B] [C].

2.8 PROPELLER FANS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.
- C. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.
- D. Fan Wheel: Replaceable, [cast] [extruded]-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
- E. Fan Drive: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- F. Fan Drive:
 - 1. Resiliently mounted to housing.
 - 2. Statically and dynamically balanced.
 - 3. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - 4. Extend grease fitting to accessible location outside of unit.
 - 5. Service Factor Based on Fan Motor Size: 1.4.
 - 6. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 7. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, [L₁₀ of 100,000 hours] <Insert life>.
 - 8. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
 - 9. Motor Pulleys: Adjustable pitch for use with motors through [5] <insert value> hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - 10. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - 11. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
- G. Accessories:
 - 1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.

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2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Weathershield Hood: Galvanized steel to match fan and accessory size.
5. Weathershield Front Guard: Galvanized steel with expanded metal screen.
6. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
7. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

H. Capacities and Characteristics:

1. Airflow: **<Insert cfm>**.
2. Fan Diameter: **<Insert inches>**.
3. Fan rpm: **<Insert value>**.
4. Brake Horsepower: **<Insert value>**.
5. Motor Size: **<Insert value>** hp.
6. Electrical Characteristics:
 - a. Volts: **<Insert value>**.
 - b. Phase: **<Insert value>**.
 - c. Hertz: **<Insert value>**.
7. Vibration Isolators:
 - a. Type: **[Elastomeric hangers] [Spring isolators] [Restrained spring isolators] <Insert type>**.
 - b. Static Deflection: **[1 inch] <Insert value>**.
8. Spark Arrestance Class: **[A] [B] [C]**.

2.9 HIGH VOLUME, LOW SPEED FANS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Delta T Corporation, dba Big Ass Fans.
2. MacroAir.
3. CaptiveAire.

B. Complete Unit:

1. Regulatory Requirements: The entire fan assembly shall be Intertek/ETL-certified and built pursuant to the construction guidelines set forth by UL standard 507 and CSA standard 22.2.
2. Sustainability Characteristics: The fan shall be designed to move an effective amount of air for cooling and destratification in industrial applications over an

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extended life. The fan components shall be designed specifically for high volume, low speed fans to ensure lower operational noise. Sound levels from the fan operating at maximum speed measured in a laboratory setting shall not exceed 55 dBA. Actual results of sound measurements in the field may vary due to sound reflective surfaces and environmental conditions.

3. Good workmanship shall be evident in all aspects of construction. Field balancing of the airfoils shall not be necessary.

C. Airfoil System:

1. The fan shall be equipped with six (6) Powerfoil airfoils of precision extruded aluminum alloy. The airfoils shall be connected by means of two (2) high strength locking bolts per airfoil. The airfoils shall be connected to the hub and interlocked with zinc plated steel retainers.
2. The fan shall be equipped with six (6) Powerfoil winglets on the ends of the airfoils. The winglets shall be molded of a polypropylene blend. The standard color of the winglet shall be "Safety Yellow."

D. Motor:

1. The fan motor shall be an AC induction type inverter rated at 1725 RPM, 200–240/400–480 VAC, 50/60 Hz, three-phase.
2. The motor shall be totally enclosed, fan cooled (TEFC) with an IP56. A B5 standard frame shall be provided for ease of service. The motor shall be manufactured with a double baked Class F insulation and be capable of continuous operation in 5°F to 104°F ambient conditions.

E. Gearbox:

1. The gearbox shall be a helical gear reducer, precision finished from hardened steel for low noise and long service life with double lip seals to retain oil and prevent contamination. The gearbox shall be lubricated for life. The gear reducer shall have a standard backlash of less than 25 arc minutes and be equipped with a 17-4 stainless steel shaft of 1-1/4" (3.2 cm) diameter.

F. Motor Frame:

1. The motor frame and mount shall be constructed of steel and powder coated for corrosion resistance and appearance. Non-visible, steel, threaded rods in each structural member of the motor frame shall provide a redundant safety feature in the event of a catastrophic event.

G. Mounting System:

1. The fan mounting system shall be designed for quick and secure installation on a variety of structural supports. The mounting yoke shall be of ASTM A-36 steel, welded construction, at least 3/16" thick, and powder coated for appearance and

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corrosion resistance. No mounting hardware or parts substitutions, including cast aluminum, are acceptable.

2. All mounting bolts shall be SAE Grade 8 or equivalent.

H. Hub:

1. The fan hub shall be made of laser cut aluminum for high strength and light weight. The hub shall consist of two aluminum plates, six (6) aluminum spars and one (1) spacer fastened with a pin and collar rivet system.
2. The hub shall be secured to the output shaft of the gearbox by means of a steel coupling interface. The hub shall incorporate six (6) safety retaining clips made of 1/4" thick steel that shall restrain the hub/airfoil assembly.

I. Safety Cable:

1. The fan shall be equipped with a safety cable that provides an additional means of securing the fan assembly to the building structure. The safety cable shall be at least 1/4" in diameter and fabricated out of 7 x 19 galvanized steel cable. The end loops shall be secured with swaged Nicopress® sleeves, pre-loaded and tested to 3,200 lbf.
2. Field construction of safety cables is not permitted.

J. Variable Frequency Drive:

1. The fan controller shall be a NEMA 4X variable frequency drive (VFD) that is factory programmed to minimize starting and braking torques. The VFD shall have touchpad controls and an LED display for controlling the fan's direction, operation, speed, and programming. The VFD may be equipped with an EMI/RFI filter to limit interference with other electronic equipment and a rotary switch disconnect for lock- out/tag-out requirements.
2. Onboard Variable Frequency Drive: The VFD may be mounted on the fan motor frame. A wall-mounted remote keypad equipped with touchpad controls and an LED display shall be provided for such installations, allowing access to all VFD functions.
3. Wall-Mounted Variable Frequency Drive: The VFD may be wall-mounted for ease of access.

K. Fire Control Panel Integration:

1. Includes a 10–30 VDC pilot relay for seamless fire control panel integration. The pilot relay can be wired Normally Open or Normally Closed in the field.

L. Guy Wires:

1. Included for installations with extension tubes 4 ft or longer to limit the potential for lateral movement.

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2.10 MOTORS:

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B. Enclosure Type: Totally enclosed, fan cooled.

2.11 SOURCE QUALITY CONTROL:

- A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Install power ventilators level and plumb.
- B. Equipment Mounting:
 - 1. Install power ventilators on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in [**Section 03 30 00 "Cast-in-Place Concrete."**] [**Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."**]
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."
- C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 07 72 00 "Roof Accessories" for installation of roof curbs.
- D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

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- E. Support suspended units from structure using threaded steel rods and [elastomeric hangers] [spring hangers] [spring hangers with vertical-limit stops] <Insert device> having a static deflection of [1 inch] <Insert deflection>. Vibration-control devices are specified in [Section 23 05 48 "Vibration and Seismic Controls for HVAC."] [Section 23 05 48.13 "Vibration Controls for HVAC."]
- F. Install units with clearances for service and maintenance.
- G. Label units according to requirements specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS:

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00 "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL:

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - 5. Adjust belt tension.
 - 6. Adjust damper linkages for proper damper operation.

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7. Verify lubrication for bearings and other moving parts.
 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic temperature-control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.4 ADJUSTING:

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

END OF SECTION

SECTION 23 37 13

AIR DIFFUSERS, REGISTERS AND GRILLS
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY:

- A. Section Includes:
 - 1. Round ceiling diffusers.
 - 2. Rectangular and square ceiling diffusers.
 - 3. Perforated diffusers.
 - 4. Louver face diffusers.
 - 5. Linear bar diffusers.
 - 6. Linear slot diffusers.
 - 7. Ceiling-integral continuous slot diffusers.
 - 8. Light troffer diffusers.
 - 9. Round induction underfloor air-distribution diffusers.
 - 10. Linear underfloor air-distribution diffuser plenums.
 - 11. High-capacity drum louver diffusers.
 - 12. High-capacity, modular-core supply grille diffusers.
 - 13. Adjustable blade face [**registers**] [**and**] [**grilles**].
 - 14. Fixed face [**registers**] [**and**] [**grilles**].
 - 15. Linear bar grilles.

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B. Related Requirements:

1. Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
 2. Section 23 37 13.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.
 3. Section 23 37 13.43 "Security Registers and Grilles" for security registers and security grilles.
 4. Section 23 37 16 "Fabric Air-Diffusion Devices" for continuous tubular diffusers.
 5. Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
 6. Section 23 37 13.13 "Air Diffusers" for various types of air diffusers.
 7. Section 23 37 13.43 "Security Registers and Grilles" for security registers and security grilles.
 8. Section 23 37 16 "Fabric Air-Diffusion Devices" for continuous tubular diffusers.
- REGISTERS AND GRILLES

1.4 ACTION SUBMITTALS:

A. Product Data: For each type of product.

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, register and grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified. Actual size of smallest diffuser, register and grille indicated.

C. Samples for Initial Selection: For diffusers, registers and grilles with factory-applied color finishes. Actual size of smallest diffuser, register and grille indicated.

D. Samples for Verification: For diffusers, registers and grilles in manufacturer's standard sizes to verify color selected. Actual size of smallest diffuser, register and grille indicated.

1.5 INFORMATIONAL SUBMITTALS:

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension assembly members.

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2. Method of attaching hangers to building structure.
 3. Size and location of initial access modules for acoustical tile.
 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
 5. Duct access panels.
- B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 ROUND CEILING DIFFUSERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material: **[Steel]** **[Aluminum]**.
- D. Finish: **[Baked enamel, white]** **[Baked enamel, color selected by Architect]** **[Anodized aluminum]** **<Insert finish>**.
- E. Face Style: **[Four]** **[Three]** **[Two]** cone.
- F. Mounting: Duct connection.
- G. Pattern: **[Fully adjustable]** **[Two-position horizontal]**.
- H. Dampers: **[Radial opposed blade]** **[Butterfly]** **[Combination damper and grid]**.
- I. Accessories:
 1. Equalizing grid.
 2. Plaster ring.
 3. Safety chain.
 4. Wire guard.
 5. Sectorizing baffles.
 6. Operating rod extension.

2.2 RECTANGULAR AND SQUARE CEILING DIFFUSERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material: **[Steel]** **[Aluminum]**.

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- D. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] [**Anodized aluminum**] <Insert finish>.
- E. Face Size: [**24 by 24-inches**] [**20 by 20-inches**] [**12 by 12-inches**] <Insert dimensions>.
- F. Face Style: [**Three cone**] [**Four cone**] [**Plaque**].
- G. Mounting: [**Surface**] [**T-bar**] [**Snap in**] [**Spline**] [**Mounting panel**].
- H. Pattern: [**Fixed**] [**Two position**] [**Adjustable**].
- I. Dampers: [**Radial opposed blade**] [**Butterfly**] [**Combination damper and grid**].
- J. Accessories:
 - 1. Equalizing grid.
 - 2. Plaster ring.
 - 3. Safety chain.
 - 4. Wire guard.
 - 5. Sectorizing baffles.
 - 6. Operating rod extension.

2.3 PERFORATED DIFFUSERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material: Steel backpan and pattern controllers, with [**steel**] [**aluminum**] face.
- D. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] [**Anodized aluminum**] <Insert finish>.
- E. Face Size: [**12 by 12-inches**] [**24 by 12-inches**] [**36 by 12-inches**] [**48 by 12-inches**] [**16 by 16-inches**] [**20 by 20-inches**] [**24 by 24-inches**] [**36 by 24-inches**] [**48 by 24-inches**] <Insert dimensions>.
- F. Duct Inlet: [**Round**] [**Square**].
- G. Face Style: [**Flush**] [**Drop extended**].
- H. Mounting: [**Surface**] [**T-bar**] [**Snap in**] [**Spline**] [**Mounting panel**].
- I. Pattern Controller: [**Four louvered deflector patches**] [**Fixed with curved blades at inlet**] [**Adjustable with louvered pattern modules at inlet**] [**None**].

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J. Dampers: [**Opposed blade**] [**Radial opposed blade**] [**Butterfly**] [**Combination damper and grid**] [**Combination volume and fire**].

K. Accessories:

1. Equalizing grid.
2. Plaster ring.
3. Safety chain.
4. Wire guard.
5. Sectorizing baffles.
6. Operating rod extension.

2.4 LOUVER FACE DIFFUSERS:

A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material: [**Steel**] [**Aluminum**].

D. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] [**Anodized aluminum**] <Insert finish>.

E. Face Size: <Insert inches>.

F. Mounting: [**Surface**] [**Surface with beveled frame**] [**T-bar**] [**Snap in**] [**Spline**] [**Mounting panel**].

G. Pattern: [**One-way**] [**Two-way**] [**Two-way corner**] [**Three-way**] [**Four-way**] [**Adjustable**] <Insert pattern> core style.

H. Dampers: [**Radial opposed blade**] [**Butterfly**] [**Combination damper and grid**].

I. Accessories:

1. Square to round neck adaptor.
2. Adjustable pattern vanes.
3. Throw reducing vanes.
4. Equalizing grid.
5. Plaster ring.
6. Safety chain.
7. Wire guard.
8. Sectorizing baffles.
9. Operating rod extension.

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2.5 LINEAR BAR DIFFUSERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material: [Steel] [Aluminum] [Stainless steel].
- D. Finish: [Baked enamel, white] [Baked enamel, color selected by Architect] <Insert finish>.
- E. Narrow Core Spacing Arrangement: 1/8-inch-thick blades spaced 1/4-inch apart; [zero] [15]-degree deflection.
- F. Wide Core Spacing Arrangement: 1/8-inch-thick blades spaced 1/2-inch apart; [zero] [15]-degree deflection.
- G. Wide Core Spacing Arrangement: 3/16-inch-thick blades spaced 1/2-inch apart; [zero] [15] [30]-degree deflection.
- H. Pencil-Proof Core Spacing Arrangement: 3/16-inch-thick blades spaced 7/16-inch apart; [zero] [15] [30]-degree deflection.
- I. [One] [Two]-Way Deflection Vanes: Extruded construction [fixed] [adjustable] louvers with removable core.
- J. Frame: [1-1/4-inches] [1-inch] [3/4-inch] [1/2-inch] [3/16-inch] wide.
- K. Mounting Frame: [Filter] <Insert frame size and style>.
- L. Mounting: [Countersunk screw] [Concealed bracket] [Spring clip].
- M. Damper Type: [Adjustable opposed-blade assembly] [Hinged single blade].
- N. Accessories: [Plaster frame] [Directional vanes] [Alignment pins] [Core clips] [Blank-off strips].

2.6 LINEAR SLOT DIFFUSERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material - Shell: [Steel] [Aluminum], [insulated] [noninsulated].
- D. Material - Pattern Controller and Tees: Aluminum.
- E. Finish - Face and Shell: [Baked enamel, black] <Insert finish>.

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- F. Finish - Pattern Controller: [**Baked enamel, black**] <Insert finish>.
- G. Finish - Tees: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**] <Insert finish>.
- H. Slot Width: [**1/2-inch**] [**3/4-inch**] [**1-inch**] [**1-1/2-inches**].
- I. Number of Slots: [**One**] [**Two**] [**Three**] [**Four**] <Insert number>.
- J. Length: [**24-inches**] [**30-inches**] [**36-inches**] [**48-inches**] [**60-inches**].
- K. Accessories: [**Plaster frame**] [**T-bar slot**] [**Center notch**] [**T-bar on inlet side**] [**T-bar on both sides**] [**T-bar clip on one side**] [**T-bar clips on both sides**].

2.7 CEILING-INTEGRAL CONTINUOUS DIFFUSERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Slot Width: [**1-inch**] [**1-1/2-inches**] [**2-inches**] [**2-1/2-inches**] [**3-inches**].
- C. Section Length: [**12-feet**] <Insert dimension>.
- D. Straight and curved sections as required to accommodate layout.
- E. Mitered tees and corners.
- F. Pattern Controllers: [**24-inches**] <Insert dimension> o.c.
- G. Material: Aluminum, extruded, heavy wall.
- H. Finishes:
 - 1. Exterior: Standard white.
 - 2. Interior: Standard black.
- I. Throw: [**Standard**] [**High**].
- J. Mounting: [**Ceiling**] [**Sidewall**].
- K. Plenum: [**Noninsulated**] [**Insulated**].
- L. Other Features:
 - 1. Painted interior.
 - 2. Blank-offs.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.8 LIGHT TROFFER DIFFUSERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material: Steel [**with external insulation**].
- D. Finish: [None] [Black enamel on visible surfaces] <Insert finish>.
- E. Slot Width: [1/2-inch] [3/4-inch] [1-inch] [1-1/2-inches].
- F. Number of Sides: [One] [Two].
- G. Length: [24-inches] [36-inches] [48-inches].
- H. Pattern: [Fixed] [Adjustable].
- I. Inlet: [Top] [Side].
- J. Inlet Size: [5-inches] [6-inches] [8-inches].

2.9 ROUND INDUCTION UNDERFLOOR AIR-DISTRIBUTION DIFFUSERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Airflow Principle: Swirl-pattern induction.
- C. Material: Plastic, high impact, and resistant to cart and foot traffic.
- D. Color: [Gray] [Black].
- E. Components:
 - 1. Diffuser core.
 - 2. Flow regulator.
 - 3. Dirt and liquid catch pan.
 - 4. Spacer flange.
 - 5. Gasketed, underfloor compression ring.

2.10 LINEAR UNDERFLOOR AIR-DISTRIBUTION DIFFUSER PLENUMS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Material: Steel.
- C. Finish: White baked acrylic.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

D. Deflection: [**Zero**] [**15**] degrees.

E. Components:

1. Aluminum diffuser core.
2. Diffuser frame.
3. Plenum, 0.034-inch steel.

2.11 HIGH-CAPACITY DRUM LOUVER DIFFUSERS:

A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

B. Airflow Principle: Extended distance for high airflow rates.

C. Material: Aluminum, heavy gage extruded.

D. Finish: White baked acrylic.

E. Border: 1-1/4-inch width with countersunk screw holes.

F. Gasket between drum and border.

G. Body: Drum shaped; adjustable vertically.

H. Blades: Individually adjustable horizontally.

I. Mounting: Surface to [**duct**] [**wall**].

J. Inlet Width: [**6-inches**] [**10-inches**] [**12-inches**] [**15-inches**] <Insert dimension>.

K. Inlet Length: [**1- inches**] [**24-inches**] [**36-inches**] [**60-inches**] <Insert dimension>.

L. Accessories:

1. Opposed-blade steel damper.
2. Duct-mounting collars with countersunk screw holes.

2.12 HIGH-CAPACITY, MODULAR-CORE SUPPLY GRILLE DIFFUSERS:

A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

B. Throw: Extended distance for airflow rates.

C. Material: Steel.

D. Grilles per Unit: [**One**] [**Two**] [**Three**] [**Four**].

E. Finish: White baked acrylic.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- F. Border: 1-1/2-inch width with countersunk screw holes.
- G. Blades:
 - 1. Airfoil, individually adjustable horizontally.
 - 2. Double deflection.
 - 3. Set in modules.
- H. Modules: Removable; rotatable.
- I. Mounting: Surface.
- J. Accessory: Opposed-blade steel damper.

2.13 REGISTERS:

- A. Adjustable Blade Face Register <Insert drawing designation>:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Material: [Steel] [Aluminum] [Stainless steel].
 - 3. Finish: [Baked enamel, white] [Baked enamel, color selected by Architect] <Insert finish>.
 - 4. Face Blade Arrangement: [Horizontal] [Vertical] spaced [**3-inches**] [**1-1/2-inches**] [**3/4-inch**] [**1/2-inch**] <Insert dimension> apart.
 - 5. Core Construction: [**Integral**] [**Removable**].
 - 6. Rear-Blade Arrangement: [**Horizontal**] [**Vertical**] spaced [**3/4-inch**] [**1/2-inch**] <Insert dimension> apart.
 - 7. Frame: [**1-1/4-inches**] [**1-inch**] <Insert dimension> wide.
 - 8. Mounting Frame: [Filter] <Insert frame size and style>.
 - 9. Mounting: [Countersunk screw] [Concealed] [Lay in].
 - 10. Damper Type: [Multishutter] [Adjustable opposed blade] [NRTL listed, opposed blade, spring closing, and with fusible link for **160 deg F**].
 - 11. Accessories:
 - a. [**Front**] [**Rear**]-blade gang operator.
 - b. Filter.
- B. Fixed Face Register <Insert drawing designation>:
 - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. Material: [**Steel**] [**Aluminum**].
 - 3. Finish: [Baked enamel, white] [Baked enamel, color selected by Architect] <Insert finish>.
 - 4. Face Blade Arrangement: [**Horizontal**] [**Vertical**] spaced [**3/4-inch**] [**1/2-inch**] <Insert dimension> apart.
 - 5. Face Arrangement: Perforated core.
 - 6. Core Construction: [**Integral**] [**Removable**].
 - 7. Frame: [**1-1/4-inches**] [**1-inch**] <Insert dimension> wide.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

8. Mounting Frame: [Filter] <Insert frame size and style>.
9. Mounting: [Countersunk screw] [Concealed] [Lay in].
10. Damper Type: [Multishutter] [Adjustable opposed blade] [NRTL listed, opposed blade, spring closing, and with fusible link for **160 deg F**].
11. Accessory: Filter.

2.14 GRILLES:

A. Adjustable Blade Face Grille <Insert drawing designation>:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Material: [Steel] [Aluminum] [Stainless steel].
3. Finish: [Baked enamel, white] [Baked enamel, color selected by Architect] <Insert finish>.
4. Face Blade Arrangement: [Horizontal] [Vertical] spaced [**3-inches**] [**1-1/2-inches**] [**3/4-inch**] [**1/2-inch**] <Insert dimension> apart.
5. Core Construction: [**Integral**] [**Removable**].
6. Rear-Blade Arrangement: [**Horizontal**] [**Vertical**] spaced [**3/4-inch**] [**1/2-inch**] <Insert dimension> apart.
7. Frame: [**1-1/4-inches**] [**1-inch**] <Insert dimension> wide.
8. Mounting Frame: [Filter] <Insert frame size and style>.
9. Mounting: [Countersunk screw] [Concealed] [Lay in].
10. Accessories:
 - a. [**Front**] [**Rear**]-blade gang operator.
 - b. Filter.

B. Fixed Face Grille <Insert drawing designation>:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Material: [**Steel**] [**Aluminum**].
3. Finish: [Baked enamel, white] [Baked enamel, color selected by Architect] <Insert finish>.
4. Face Blade Arrangement: [**Horizontal**] [**Vertical**]; spaced [**3/4-inch**] [**1/2-inch**] <Insert dimension> apart.
5. Face Arrangement: Perforated core.
6. Core Construction: [**Integral**] [**Removable**].
7. Frame: [**1-1/4-inches**] [**1-inch**] <Insert dimension> wide.
8. Mounting Frame: [Filter] <Insert frame size and style>.
9. Mounting: [Countersunk screw] [Concealed] [Lay in].
10. Accessory: Filter.

C. Linear Bar Grilles <Insert drawing designation>

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Material: [**Steel**] [**Aluminum**].

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3. Finish: [Baked enamel, white] [Baked enamel, color selected by Architect] <Insert finish>.
4. Face Blade Arrangement: [**Horizontal**] [**Vertical**]; spaced [**1/2-inch**] <Insert dimension> apart.
5. Face Arrangement: Perforated core.
6. Core Construction: [**Integral**] [**Removable**].
7. Distribution plenum.
 - a. Internal insulation.
 - b. Inlet damper.
8. Frame: [**1-1/4-inches**] [**1-inch**] <Insert dimension> wide.
9. Mounting Frame: [Filter] <Insert frame size and style>.
10. Mounting: [Countersunk screw] [Concealed] [Lay in].
11. Damper Type: [Adjustable opposed blade] [NRTL listed, opposed blade, spring closing, and with fusible link for **160 deg F**].

2.15 SOURCE QUALITY CONTROL:

- A. Verification of Performance: Rate diffusers, registers and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine areas where diffusers, registers and grilles are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

- A. Install diffusers, registers and grilles level and plumb.
- B. Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3.3 ADJUSTING:

- A. After installation, adjust diffusers, registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 23 37 23

HVAC GRAVITY VENTILATORS
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections:

Section 07 92 00 – JOINT SEALANTS

Section 23 05 53 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

Section 23 31 13 – METAL DUCTS

Section 23 31 16 – NONMETAL DUCTS

1.3 SUMMARY:

- A. Section Includes:
 - 1. Louvered-penthouse ventilators.
 - 2. Roof hoods.
 - 3. Goosenecks.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1.4 PERFORMANCE REQUIREMENTS:

- A. Delegated Design: Design ventilators, including comprehensive engineering analysis by a qualified professional engineer, using structural [**and seismic**] performance requirements and design criteria indicated.
- B. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.
 - 1. Wind Loads: Determine loads based on pressures as indicated on Drawings.
 - 2. Wind Loads: Determine loads based on a uniform pressure of [**20 lbf/sq. ft.**] [**30 lbf/sq. ft.**] **<Insert design wind pressure>**, acting inward or outward.
 - 3. Wind Loads: Determine loads based on pressures indicated below:
 - a. Corner Zone: Within **<Insert distance>** of building corners, uniform pressure of **<Insert design wind pressure>**, acting inward, and **<Insert design wind pressure>**, acting outward.
 - b. Other Than Corner Zone: Uniform pressure of **<Insert design wind pressure>**, acting inward, and **<Insert design wind pressure>**, acting outward.
- C. Seismic Performance: Ventilators, including attachments to other construction, shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**] **<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified [**and the unit will be fully operational after the seismic event**]."
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.
 - 1. Temperature Change (Range): [**120 deg. F, ambient; 180 deg. F**] **<Insert temperature range>**, material surfaces.
- E. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

1.5 ACTION SUBMITTALS:

- A. Product Data: For each type of product indicated. [**For louvered-penthouse ventilators specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.**]

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

B. Sustainable Design Submittals:

1. [<Double click to insert sustainable design text for HVAC units.>](#)

C. Shop Drawings: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.

1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

D. Samples: For each exposed product and for each color and texture specified.

E. Samples for Initial Selection: For units with factory-applied color finishes.

F. Samples for Verification: For each type of louvered-penthouse ventilator indicated, in manufacturer's standard size.

G. Delegated-Design Submittal: For shop-fabricated ventilators indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of shop-fabricated ventilators.

1.6 INFORMATIONAL SUBMITTALS:

A. Coordination Drawings: Roof framing plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which roof curbs and ventilators will be attached.
2. Sizes and locations of roof openings.

B. Seismic Qualification Certificates: For ventilators, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.7 QUALITY ASSURANCE:

A. Welding Qualifications: Qualify procedures and personnel according to the following:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
2. AWS D1.3, "Structural Welding Code - Sheet Steel."

1.8 COORDINATION:

- A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.
- B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.
- C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 zinc coating, mill phosphatized.
- D. Stainless-Steel Sheet: ASTM A 666, Type 304, with No. [4] [6] finish.
- E. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.
 1. Use types and sizes to suit unit installation conditions.
 2. Use **[Phillips flat] [hex-head or Phillips pan]**-head screws for exposed fasteners unless otherwise indicated.
- F. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
- G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.2 FABRICATION, GENERAL:

- A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
- C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
- D. Fabricate supports, anchorages, and accessories required for complete assembly.
- E. Perform shop welding by AWS-certified procedures and personnel.

2.3 LOUVERED-PENTHOUSE VENTILATORS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Construction: All-welded assembly with [**4-inch**] [**6-inch**]-deep louvers, mitered corners, and [**aluminum**] [**galvanized-steel**] [**stainless-steel**] sheet roof [**with mineral-fiber insulation and vapor barrier**].
- C. Frame and Blade Material and Nominal Thickness: Extruded aluminum, of thickness required to comply with structural performance requirements, but not less than 0.080-inch for frames and [**0.080-inch**] [**0.060-inch**] for blades [**with condensate deflectors**].
 - 1. Blade Spacing: **<Insert inches>**.
 - 2. Blade Angle: **<Insert number>** degrees.
 - 3. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
 - 4. Exterior Corners: Prefabricated corner units with [**mitered and welded blades**] [**mitered blades with concealed close-fitting splices**] and with [**fully recessed**] [**semirecessed**] mullions at corners.
- D. Frame and Blade Material and Nominal Thickness: Galvanized-steel sheet, of thickness required to comply with structural performance requirements, but not less than 0.052-inch for frames and [**0.040-inch**] [**0.052-inch**] [**0.064-inch**] for blades [**with condensate deflectors**].
 - 1. Blade Spacing: **<Insert inches>**.
 - 2. Blade Angle: **<Insert number>** degrees.
 - 3. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
 - 4. Exterior Corners: Prefabricated corner units with [**mitered and welded blades**] [**mitered blades with concealed close-fitting splices**] and with [**fully recessed**] [**semirecessed**] mullions at corners.
- E. Frame and Blade Material and Nominal Thickness: Stainless-steel sheet, of thickness required to comply with structural performance requirements, but not less than [**0.050-inch**] [**0.062-inch**], with grain running [**parallel**] [**perpendicular**] to length of blades and frame members [**with condensate deflectors**].

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Blade Spacing: <Insert inches>.
 2. Blade Angle: <Insert number> degrees.
 3. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
 4. Exterior Corners: Prefabricated corner units with [mitered and welded blades] [mitered blades with concealed close-fitting splices] and with [fully recessed] [semirecessed] mullions at corners.
- F. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
1. Configuration: [Self-flashing without a cant strip, with] [Built-in cant and] [Built-in raised cant and] mounting flange.
 2. Overall Height: [8 inches] [9-1/2 inches] [12 inches] [16 inches] [18 inches].
- G. Bird Screening: [Galvanized-steel, 1/2-inch-square mesh, 0.041-inch wire] [Aluminum, 1/2-inch-square mesh, 0.063-inch wire] [Flattened, expanded aluminum, 3/4 by 0.050-inch-thick] [Stainless-steel, 1/2-inch-square mesh, 0.047-inch wire].
- H. Insect Screening: [Aluminum, 18-by-16 mesh, 0.012-inch] [Stainless-steel, 18-by-18 mesh, 0.009-inch] wire.
- I. Galvanized-Steel Sheet Finish:
1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
 2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
 3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.
 - a. Color and Gloss: [As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range].
- J. Accessories:
1. Dampers:
 - a. Location: [Penthouse neck] [Inside louver face].
 - b. Control: [Manual] [Motorized].

K. Capacities and Characteristics:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Height: **<Insert inches>**.
2. Width and Depth: **<Insert inches>** by **<Insert inches>**.
3. Free Area: Not less than **[5.0 sq. ft.] [6.0 sq. ft.] [7.0 sq. ft.] <Insert free area>** for 48-inch-wide by 48-inch-high louver.
4. Air Performance: Not more than **[0.10-inch wg] <Insert pressure>** static pressure drop at **[600-fpm] [700-fpm] [800-fpm] <Insert velocity>** free-area **[exhaust] [intake]** velocity.
5. Wind-Driven Rain Performance: Not less than **[99] [95] [80] <Insert number>** percent effectiveness when subjected to a rainfall rate of **[3 inches per hour and a wind speed of 29 mph] [8 inches per hour and a wind speed of 50 mph]** at a core-area intake velocity of **[300 fpm] [400 fpm] [500 fpm] <Insert velocity>**.

2.4 ROOF HOODS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 6-6 and 6-7.
- C. Materials: **[Galvanized-steel sheet, minimum 0.064-inch-thick base and 0.040-inch-thick hood] [Aluminum sheet, minimum 0.063-inch-thick base and 0.050-inch-thick hood]**; suitably reinforced.
- D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
 1. Configuration: **[Self-flashing without a cant strip, with] [Built-in cant and] [Built-in raised cant and]** mounting flange.
 2. Overall Height: **[8 inches] [9-1/2 inches] [12 inches] [16 inches] [18 inches]**.
- E. Bird Screening: **[Galvanized-steel, 1/2-inch-square mesh, 0.041-inch wire] [Aluminum, 1/2-inch-square mesh, 0.063-inch wire] [Flattened, expanded aluminum, 3/4 by 0.050-inch-thick] [Stainless-steel, 1/2-inch-square mesh, 0.047-inch wire]**.
- F. Insect Screening: **[Aluminum, 18-by-16 mesh, 0.012-inch] [Stainless-steel, 18-by-18 mesh, 0.009-inch]** wire.
- G. Galvanized-Steel Sheet Finish:
 1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
 2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.
 - a. Color and Gloss: **[As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range]**.

H. Capacities and Characteristics:

1. Height: **<Insert inches>**.
2. Width and Depth: **<Insert inches> by <Insert inches>**.
3. Free Area: Not less than **[5.0 sq. ft.] [6.0 sq. ft.] [7.0 sq. ft.] <Insert free area>** for 48-inch-wide by 48-inch-high louver.
4. Air Performance: Not more than **[0.10-inch wg] <Insert pressure>** static pressure drop at **[600-fpm] [700-fpm] [800-fpm] <Insert velocity>** free-area **[exhaust] [intake]** velocity.

2.5 GOOSENECKS:

- A. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 6-5; with a minimum of 0.052-inch-thick, galvanized-steel sheet.
- B. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
 1. Configuration: **[Self-flashing without a cant strip, with] [Built-in cant and] [Built-in raised cant and]** mounting flange.
 2. Overall Height: **[8 inches] [9-1/2 inches] [12 inches] [16 inches] [18 inches]**.
- C. Bird Screening: **[Galvanized-steel, 1/2-inch-square mesh, 0.041-inch wire] [Aluminum, 1/2-inch-square mesh, 0.063-inch wire] [Flattened, expanded aluminum, 3/4 by 0.050-inch-thick] [Stainless-steel, 1/2-inch-square mesh, 0.047-inch wire]**.
- D. Insect Screening: **[Aluminum, 18-by-16 mesh, 0.012-inch] [Stainless-steel, 18-by-18 mesh, 0.009-inch]** wire.
- E. Galvanized-Steel Sheet Finish:
 1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.
 - a. Color and Gloss: **[As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range].**

F. Capacities and Characteristics:

1. Height: **<Insert inches>**.
2. Width and Depth: **<Insert inches>** by **<Insert inches>**.
3. Free Area: Not less than **[5.0 sq. ft.] [6.0 sq. ft.] [7.0 sq. ft.] <Insert free area>** for 48-inch-wide by 48-inch-high louver.
4. Air Performance: Not more than **[0.10-inch wg] <Insert pressure>** static pressure drop at **[600-fpm] [700-fpm] [800-fpm] <Insert velocity>** free-area **[exhaust] [intake]** velocity.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
- B. Install goosenecks on curb base where throat size exceeds **[9 by 9 inches] <Insert measurement>**.
- C. Install gravity ventilators with clearances for service and maintenance.
- D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 07 92 00 – JOINT SEALANTS for sealants applied during installation.
- F. Label gravity ventilators according to requirements specified in Section 23 05 53 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT.
- G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.2 CONNECTIONS:

- A. Duct installation and connection requirements are specified in Section 23 31 13 – METAL DUCTS and Section 23 31 16 – NONMETAL DUCTS. Drawings indicate general arrangement of ducts and duct accessories.

3.3 ADJUSTING:

- A. Adjust damper linkages for proper damper operation.

END OF SECTION

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

SECTION 23 72 00

AIR-TO-AIR ENERGY RECOVERY EQUIPMENT (FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections:

[Section 03 30 00 – CAST-IN-PLACE CONCRETE]

[Section 03 30 53 – MISCELLANEOUS CAST-IN-PLACE CONCRETE]

Section 07 72 00 – ROOF ACCESSORIES

Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

Section 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC

[Section 23 11 23 – FACILITY NATURAL-GAS PIPING]

[Section 23 11 26 – FACILITY LIQUEFIED-PETROLEUM GAS PIPING]

Section 23 21 13 – HYDRONIC PIPING

Section 23 21 16 – HYDRONIC PIPING SPECIALTIES

Section 23 22 13 – STEAM AND CONDENSATE HEATING PIPING

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

Section 23 22 16 – STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

Section 23 31 13 – METAL DUCTS

Section 23 33 00 – AIR DUCT ACCESSORIES

Section 23 51 23 – GAS VENTS

1.3 SUMMARY:

A. Section Includes:

1. Heat wheels.
2. Heat-pipe heat exchangers.
3. Fixed-plate sensible heat exchangers.
4. Fixed-plate total heat exchangers.
5. Packaged energy recovery units.

1.4 PERFORMANCE REQUIREMENTS:

- #### A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- #### B. Seismic Performance: Air-to-air energy recovery equipment shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7] <Insert requirement>.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified [**and the unit will be fully operational after the seismic event**]."

1.5 ACTION SUBMITTALS:

- #### A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- #### B. Sustainable Design Submittals:
1. <Double click to insert sustainable design text for HVAC units.>
- #### C. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Wiring Diagrams: For power, signal, and control wiring.
- D. Delegated-Design Submittal: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 1. Detail fabrication and assembly of air-to-air energy recovery equipment.
 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 3. Design Calculations: Calculate requirements for selecting vibration isolators [**and seismic restraints**] and for designing vibration isolation bases.

1.6 INFORMATIONAL SUBMITTALS:

- A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 1. Suspended ceiling components.
 2. Structural members to which equipment or suspension systems will be attached.
- B. Seismic Qualification Data: Certificates, for air-to-air energy recovery equipment, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS:

- A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS:

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: [**One**] **<Insert number>** set(s) of each type of filter specified.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Fan Belts: [**One**] <Insert number> set(s) of belts for each belt-driven fan in energy recovery units.
3. Wheel Belts: [**One**] <Insert number> set(s) of belts for each heat wheel.

1.9 QUALITY ASSURANCE:

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ARI Compliance:
 1. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
 2. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils."
- C. ASHRAE Compliance:
 1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
 2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."
- D. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.
- E. UL Compliance:
 1. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."
 2. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

1.10 COORDINATION:

- A. Coordinate layout and installation of air-to-air energy recovery equipment and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.

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- C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.11 WARRANTY:

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Packaged Energy Recovery Units: [**Two**] **<Insert number>** years.
 - 2. Warranty Period for Fixed-Plate Total Heat Exchangers: [**10**] **<Insert number>** years.
 - 3. **<Insert components requiring extended warranty>**.

PART 2 - PRODUCTS

2.1 HEAT WHEELS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Casing:
 - 1. Steel with standard factory-painted finish.
 - 2. Integral purge section limiting carryover of exhaust air to between [**0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg**] **<Insert value>** differential pressure.
 - 3. Casing seals on periphery of rotor and on duct divider and purge section.
 - 4. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings [**or permanently lubricated bearings**]. Support horizontal rotors on tapered roller bearing.
- C. Rotor: Aluminum segmented wheel strengthened with radial spokes [, **with nontoxic, noncorrosive, silica-gel desiccant coating**].
 - 1. Maximum Solid Size for Media to Pass: [**500**] [**800**] [**1200**] micrometer.
- D. Rotor: [**Glass-fiber**] [**Polymer**] segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.
 - 1. Maximum Solid Size for Media to Pass: [**800**] [**1200**] micrometer.
- E. Drive: Fractional horsepower motor and gear reducer [, **with speed changed by variable frequency controller**] and self-adjusting multilink belt around outside of rotor.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Controls:

1. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
2. Variable frequency controller, factory mounted and wired, permitting input of field connected 4-20 mA or 1-10-V control signal.
3. Variable frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
4. Variable frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain [**exhaust temperature above freezing and**] air differential temperature above set point. Rotor speed shall increase to maximum when exhaust-air temperature is less than outdoor-air temperature.
5. Pilot-Light Indicator: Display rotor rotation and speed.
6. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.

G. Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, viscous-coated, flat-panel type.
4. Thickness: [**1 inch**] [**2 inches**].
5. Dust-Holding Capacity: <Insert lb>.
6. Initial Resistance: <Insert inches wg>.
7. Recommended Final Resistance: <Insert inches wg>.
8. Minimum Arrestance: [**80**] <Insert value>, according to ASHRAE 52.1.
9. MERV: [**5**] <Insert value>, according to ASHRAE 52.2.
10. Media: Interlaced glass fibers sprayed with nonflammable adhesive [**and antimicrobial agent**].
11. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

H. Extended-Surface, Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3. Factory-fabricated, dry, extended-surface type.
4. Thickness: [**1 inch**] [**2 inches**] [**4 inches**].
5. Dust-Holding Capacity: **<Insert lb>**.
6. Initial Resistance: **<Insert inches wg>**.
7. Recommended Final Resistance: **<Insert inches wg>**.
8. Minimum Arrestance: [**90**] **<Insert value>**, according to ASHRAE 52.1.
9. MERV: [**7**] **<Insert value>**, according to ASHRAE 52.2.
10. Media: Fibrous material formed into deep-V-shaped pleats [**with antimicrobial agent**] and held by self-supporting wire grid.
11. Media-Grid Frame: [**Nonflammable cardboard**] [**Galvanized steel**] [**Fire-retardant, 3/4-inch particleboard with gaskets**].
12. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

I. Extended-Surface, Nonsupported-Media Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, dry, extended-surface, self-supporting type.
4. Dust-Holding Capacity: **<Insert lb>**.
5. Initial Resistance: **<Insert inches wg>**.
6. Recommended Final Resistance: **<Insert inches wg>**.
7. Minimum Arrestance: [**95**] **<Insert value>**, according to ASHRAE 52.1.
8. MERV: [**13**] **<Insert value>**, according to ASHRAE 52.2.
9. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions [**and antimicrobial agent**].
10. Filter-Media Frame: [**Galvanized steel**] [**Hard polyurethane foam**].
11. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks [**with space for prefilter**].

2.2 HEAT-PIPE HEAT EXCHANGERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Casing: Galvanized-steel flanged casing, with airtight partition between airstreams.
- C. Refrigerant: ASHRAE 15, Group 1. **<Insert requirements>**.
- D. Tubes: [**5/8-inch-**] [**1-inch-**] diameter, [**aluminum**] [**copper**] **<Insert material>**.
- E. Fins: [**Aluminum**] [**Integral aluminum**] [**Copper**].
 1. Fin Spacing: [**0.125 inch**] [**0.091 inch**] [**0.071 inch**] [**0.067 inch**] [**0.056 inch**] [**0.0075 inch**] **<Insert fins per inch>**.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Fin and Tube Joint: [**Mechanical bond**] [**Silver brazed**].

- F. Coating: [**Thermoplastic vinyl**] [**Epoxy**] [**Synthetic resin**] [**Phenolic**] [**Polytetrafluoroethylene**] [**Vinyl ester**] <Insert coating>; apply to supply and exhaust.
- G. Control: Integral plenum containing heat-pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.
- H. Control: Pivot center of bottom of heat-pipe coil on shaft and bearings to tilt coil. Include tilt controls with electronic controller, electric actuator and linkage, thermostats, sensors, and polyester fabric with PVC-coated flexible connector for automatic supply temperature regulation, summer/winter changeover, and frost protection.

2.3 FIXED-PLATE SENSIBLE HEAT EXCHANGERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Casing: [**Aluminum**] [**Galvanized steel**] [**Enameled steel, with galvanized-steel liner**] [**Enameled steel**] with duct collars.
- D. Casing Insulation: [**1/2-inch-thick, foil-faced glass fiber**] [**1-inch-thick, foil-faced glass fiber**] [**1-inch thick, ASTM C 1071 with coated surface**] [**1-inch thick, fiber free**].
- E. Drain Pan: [**Same material as casing, with drain connections on exhaust and supply side**] [**Molded ABS covering bottom of case, with drain connections on exhaust and supply side**].
 - 1. Comply with requirements in ASHRAE 62.1.
- F. Plates: Evenly spaced and sealed and arranged for counter airflow.
 - 1. Plate Material: [**Embossed aluminum**] [**Stainless steel**] [**Polypropylene copolymer (high-density plastic)**].
 - 2. Plate Coating: [**Epoxy**] [**Air-dried phenolic**].
- G. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.
- H. Water Wash: Automatic system, with spray manifold to individual spray tubes or traversing type with stainless-steel-screw operating mechanism and electric motor drive; activated by time clock [, **with detergent injection**].

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

I. Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, viscous-coated, flat-panel type.
4. Thickness: [**1 inch**] [**2 inches**].
5. Initial Resistance: <**Insert inches wg**>.
6. Recommended Final Resistance: <**Insert inches wg**>.
7. Minimum Arrestance: [**80**] <**Insert value**>, according to ASHRAE 52.1.
8. MERV: [**5**] <**Insert value**>, according to ASHRAE 52.2.
9. Media: Interlaced glass fibers sprayed with nonflammable adhesive [**and antimicrobial agent**].
10. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

J. Extended-Surface, Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, dry, extended-surface type.
4. Thickness: [**1 inch**] [**2 inches**] [**4 inches**].
5. Initial Resistance: <**Insert inches wg**>.
6. Recommended Final Resistance: <**Insert inches wg**>.
7. Minimum Arrestance: [**90**] <**Insert value**>, according to ASHRAE 52.1.
8. MERV: [**7**] <**Insert value**>, according to ASHRAE 52.2.
9. Media: Fibrous material formed into deep-V-shaped pleats [**with antimicrobial agent**] and held by self-supporting wire grid.
10. Media-Grid Frame: [**Nonflammable cardboard**] [**Galvanized steel**] [**Fire-retardant, 3/4-inch particleboard with gaskets**].
11. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

K. Extended-Surface, Nonsupported-Media Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, dry, extended-surface, self-supporting type.
4. Initial Resistance: <**Insert inches wg**>.
5. Recommended Final Resistance: <**Insert inches wg**>.
6. Minimum Arrestance: [**95**] <**Insert value**>, according to ASHRAE 52.1.
7. MERV: [**13**] <**Insert value**>, according to ASHRAE 52.2.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

8. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions [**and antimicrobial agent**].
9. Filter-Media Frame: [**Galvanized steel**] [**Hard polyurethane foam**].
10. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks [**with space for prefilter**].

2.4 FIXED-PLATE TOTAL HEAT EXCHANGERS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Casing: Galvanized steel.
- C. Plates: Evenly spaced and sealed and arranged for counter airflow.
 1. Plate Material: Chemically treated paper with selective hydroscopicity and moisture permeability, and gas barrier properties.
- D. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.
- E. Disposable Panel Filters:
 1. Comply with NFPA 90A.
 2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 3. Factory-fabricated, viscous-coated, flat-panel type.
 4. Thickness: [**1 inch**] [**2 inches**].
 5. Initial Resistance: **<Insert inches wg>**.
 6. Recommended Final Resistance: **<Insert inches wg>**.
 7. Minimum Arrestance: [**80**] **<Insert value>**, according to ASHRAE 52.1.
 8. MERV: [**5**] **<Insert value>**, according to ASHRAE 52.2.
 9. Media: Interlaced glass fibers sprayed with nonflammable adhesive [**and antimicrobial agent**].
 10. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
- F. Extended-Surface, Disposable Panel Filters:
 1. Comply with NFPA 90A.
 2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 3. Factory-fabricated, dry, extended-surface type.
 4. Thickness: [**1 inch**] [**2 inches**] [**4 inches**].
 5. Initial Resistance: **<Insert inches wg>**.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

6. Recommended Final Resistance: <Insert inches wg>.
7. Minimum Arrestance: [90] <Insert value>, according to ASHRAE 52.1.
8. MERV: [7] <Insert value>, according to ASHRAE 52.2.
9. Media: Fibrous material formed into deep-V-shaped pleats [**with antimicrobial agent**] and held by self-supporting wire grid.
10. Media-Grid Frame: [**Nonflammable cardboard**] [**Galvanized steel**] [**Fire-retardant, 3/4-inch particleboard with gaskets**].
11. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

2.5 PACKAGED ENERGY RECOVERY UNITS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, [**gasketed and calked weathertight,**] [**hinged access doors**] [**removable panels**] with neoprene gaskets for inspection and access to internal parts, minimum [**1-inch-**] [**2-inch-**] <Insert thickness> thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.
 1. Inlet: Weatherproof [**hood**] [**louver**], with damper for exhaust and supply.
 - a. Exhaust: [**Gravity backdraft damper**] [**Spring-return, two-position, motor-operated damper**].
 - b. Supply: [**Gravity backdraft damper**] [**Spring-return, two-position, motor-operated damper**].
 2. Roof Curb: Refer to Section 07 72 00 – ROOF ACCESSORIES for roof curbs and equipment supports.
- D. Heat Recovery Device: [**Heat wheel**] [**Heat-pipe heat exchanger**] [**Fixed-plate heat exchanger**].
- E. Supply and Exhaust Fans: [**Forward-curved, centrifugal**] [**Propeller**] [**Backward-inclined, SWSI centrifugal**] [**Backward-inclined, plenum centrifugal**] fan with [**spring isolators**] [**restrained, spring isolators**] [**spring hangers**] [**spring hangers with vertical-limit stops**] [**and**] [**insulated**] flexible duct connections.
 1. Motor and Drive: [**Direct driven**] [**Belt driven with adjustable sheaves, motor mounted on adjustable base**] [**Drive type indicated on Drawings**].
 2. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Spring isolators on each fan having [**1-inch**] **<Insert deflection>** static deflection.

F. Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, viscous-coated, flat-panel type.
4. Thickness: [**1 inch**] [**2 inches**].
5. Initial Resistance: **<Insert inches wg>**.
6. Recommended Final Resistance: **<Insert inches wg>**.
7. Minimum Arrestance: [**80**] **<Insert value>**, according to ASHRAE 52.1.
8. MERV: [**5**] **<Insert value>**, according to ASHRAE 52.2.
9. Media: Interlaced glass fibers sprayed with nonflammable adhesive [**and antimicrobial agent**].
10. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

G. Extended-Surface, Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, dry, extended-surface type.
4. Thickness: [**1 inch**] [**2 inches**] [**4 inches**].
5. Initial Resistance: **<Insert inches wg>**.
6. Recommended Final Resistance: **<Insert inches wg>**.
7. Minimum Arrestance: [**90**] **<Insert value>**, according to ASHRAE 52.1.
8. MERV: [**7**] **<Insert value>**, according to ASHRAE 52.2.
9. Media: Fibrous material formed into deep-V-shaped pleats [**with antimicrobial agent**] and held by self-supporting wire grid.
10. Media-Grid Frame: [**Nonflammable cardboard**] [**Galvanized steel**] [**Fire-retardant, 3/4-inch particleboard with gaskets**].
11. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

H. Extended-Surface, Nonsupported-Media Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, dry, extended-surface, self-supporting type.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

4. Initial Resistance: **<Insert inches wg>**.
 5. Recommended Final Resistance: **<Insert inches wg>**.
 6. Minimum Arrestance: **[95] <Insert value>**, according to ASHRAE 52.1.
 7. MERV: **[13] <Insert value>**, according to ASHRAE 52.2.
 8. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions [**and antimicrobial agent**].
 9. Filter-Media Frame: **[Galvanized steel] [Hard polyurethane foam]**.
 10. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks [**with space for prefilter**].
- I. Cooling Coils: Rated according to ARI 410 and ASHRAE 33[, **and bearing the ARI label**].
1. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
 2. Casing: **[Manufacturer's standard material] [Aluminum] [Galvanized steel] [Stainless steel] <Insert material>**.
 3. Tubes: **[Copper] <Insert material>**.
 4. Tube Headers: **[Manufacturer's standard material] [Copper] [Carbon steel] [Red brass] <Insert material>**.
 5. Fins: **[Aluminum] [Copper] <Insert material>**.
 6. Fin and Tube Joint: Mechanical bond.
 7. Leak Test: Coils shall be leak tested with air under water.
 8. Refrigerant Coils:
 - a. Capacity Reduction: Circuit coils for **[face] [row] [interleaved]** control.
 - b. Suction and Distributor: Seamless copper tube with brazed joints.
 9. Coating: Phenolic epoxy corrosion-protection coating after assembly.
- J. Cooling-Coil Condensate Drain Pans:
1. Fabricated from **[galvanized] [stainless]**-steel sheet and sloped in multiple planes to collect and drain condensate from cooling coils, coil piping connections, coil headers, and return bends.
 2. Complying with requirements in ASHRAE 62.1.
 3. Drain Connections: At low point of pan with minimum **<Insert size>** threaded nipple.
 4. Units with stacked coils shall have an intermediate drain pan to collect and drain condensate from top coil.
- K. Hot-Water Coils: Rated according to ARI 410 and ASHRAE 33[, **and bearing the ARI label**].
1. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Casing: [**Manufacturer's standard material**] [**Aluminum**] [**Galvanized steel**] [**Stainless steel**] <Insert material>.
 3. Tubes: [**Copper**] <Insert material>.
 4. Tube Headers: [**Manufacturer's standard material**] [**Copper**] [**Carbon steel**] [**Red brass**] <Insert material>.
 5. Fins: [**Aluminum**] [**Copper**] <Insert material>.
 6. Fin and Tube Joint: Mechanical bond.
 7. Leak Test: Coils shall be leak tested with air under water.
 8. Coating: Phenolic epoxy corrosion-protection coating after assembly.
- L. [**Nonfreeze Type**] Steam Coils: Rated according to ARI 410 and ASHRAE 33[, and bearing the ARI label].
1. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
 2. Casing: [**Manufacturer's standard material**] [**Aluminum**] [**Galvanized steel**] [**Stainless steel**] <Insert material>.
 3. Tubes: [**Copper**] <Insert material>.
 4. Tube Headers: [**Manufacturer's standard material**] [**Copper**] [**Carbon steel**] [**Red brass**] <Insert material>.
 5. Fins: [**Aluminum**] [**Copper**] <Insert material>.
 6. Fin and Tube Joint: Mechanical bond.
 7. Leak Test: Coils shall be leak tested with air under water.
 8. Coating: Phenolic epoxy corrosion-protection coating after assembly.
- M. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
1. Casing Assembly: [**Slip-in**] [**Flanged**] type with galvanized-steel frame.
 2. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service.
 3. Sheathed Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
 4. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 5. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 6. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 7. Control Panel: [**Unit**] [**Remote**] mounted with disconnecting means and overcurrent protection.
 - a. [**Magnetic**] [**Mercury**] contactor.

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- b. Solid-state, stepless pulse controller.
- c. Toggle switches, one per step.
- d. Step controller.
- e. Time-delay relay.
- f. Pilot lights, one per step.
- g. Airflow proving switch.

N. Indirect-Fired Gas Furnaces:

- 1. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
 - a. AGA Approval: Furnace shall bear label of AGA.
- 2. Burners: [**Aluminized steel with stainless-steel inserts**] [**Stainless steel**].
 - a. Ignition: Electronically controlled electric spark with flame sensor.
 - b. High-Altitude [**Model**] [**Kit**]: For Project at elevations more than 2000 feet above sea level.
- 3. Heat-Exchanger Drain Pan: Stainless steel.
- 4. Venting: Gravity vented.
- 5. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
- 6. Gas Control Valve: [**Single stage**] [**Two stage**] [**Electronic modulating**].
- 7. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff. Control devices and control sequence shall comply with requirements of [**FMG**] [**IRI**] <**Insert agency**>.
- 8. Access: Fabricate section to allow removal and replacement of furnace and to allow in-place access for service.

O. Piping and Wiring: Fabricate units with space within housing for piping and electrical conduits. Wire motors and controls so only external connections are required during installation.

- 1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
- 2. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
- 3. Include [**fused**] [**nonfused**] disconnect switches.
- 4. Variable-speed controller to vary fan capacity from 100 to approximately [**50**] <**Insert number**> percent.

P. Accessories:

- 1. Roof Curb: [**Steel**] [**Galvanized steel**] [**Aluminum**] with gasketing, and factory-installed wood nailer; complying with NRCA standards; minimum height of [**14 inches**] [**24 inches**] <**Insert height**>.

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2. Intake weather hood with 2-inch-thick filters.
3. Louvered intake weather hood with 2-inch-thick filters in V-bank configuration.
4. Exhaust weather hood with birdscreen.
5. Low-Leakage, Isolation Dampers: Double-skin, airfoil-blade, **[galvanized-steel]** **[aluminum]** **[extruded-aluminum]** dampers with compressible jamb seals and extruded-vinyl blade edge seals, in **[opposed]** **[parallel]**-blade arrangement with **[cadmium-plated]** steel operating rods rotating in **[stainless-steel sleeve]** **[sintered bronze or nylon]** bearings mounted in a single **[galvanized-steel]** **[aluminum]** **[extruded-aluminum]** frame, with operating rods connected with a common linkage, and electric damper operator factory wired. Leakage rate shall not exceed 5 cfm/sq. ft. at 1-inch wg and 9 cfm/sq. ft. at 4-inch wg.
6. Isolation Dampers: Opposed-blade, **[galvanized-steel]** **[aluminum]** **[extruded-aluminum]** dampers with **[cadmium-plated]** steel operating rods rotating in sintered bronze or nylon bearings mounted in a single **[galvanized-steel]** **[aluminum]** **[extruded-aluminum]** frame with operating rods connected with a common linkage, and electric damper operator factory wired. Blades shall have gaskets and edge seals, and shall be mechanically fastened to operating rod.
7. Duct flanges.
8. Rubber-in-shear isolators for ceiling-mounted units.
9. Hinged access doors with quarter-turn latches.
10. Drain pans for condensate removal **[complying with ASHRAE 62.1]**.
11. Automatic, in-place, spray-wash system.
12. Weatherproofing for tilt-control system.

2.6 CONTROLS:

- A. Time Clock: Solid-state, programmable, microprocessor-based unit for **[wall mounting]** **[mounting in outdoor NEMA 250, Type 3R enclosure]** with up to eight on/off cycles per day and battery backup protection of program settings against power failure to energize unit.
- B. Motion (Occupancy) Sensor: Passive infrared sensor for **[wall]** **[ceiling]** mounting with adjustable time-off delay of up to 30 minutes to energize unit.
- C. Carbon Monoxide Sensor: Adjustable control from 600 to 2000 ppm for **[wall]** **[duct]** mounting with digital display and computer/building management system interface to energize unit.
- D. Humidistat: Adjustable, wall-mounted instrument to energize unit when space relative humidity exceeds **[50 percent]** **<Insert relative humidity>**.
- E. Chilled-Water-Cooling-Coils Controls:
 1. **[Factory-mounted sensor in unit discharge]** **[Remote-mounted sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to modulate factory-**[mounted]** **[furnished]** coil-control valve to maintain temperature.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. Wall-mounted, space-temperature sensor with **[temperature adjustment]** **[unit-mounted temperature adjustment]** **[adjustment on remote-control panel]** to modulate factory-**[mounted]** **[furnished]** coil-control valve to maintain temperature.

F. Refrigerant-Cooling-Coils Controls:

1. **[Factory-mounted sensor in unit discharge]** **[Remote-mounted sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to control remote condensing unit to maintain temperature.
2. Wall-mounted, space-temperature sensor with **[temperature adjustment]** **[unit-mounted temperature adjustment]** **[adjustment on remote-control panel]** controls remote condensing unit to maintain temperature.
3. Cooling Capacity Control: **[On/off]** **[Multiple steps]** **<Insert type>**.

G. **[Hot-Water-]** **[and]** **[Steam-]**Coils Controls:

1. **[Factory-mounted sensor in unit discharge]** **[Remote-mounted sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to modulate factory-**[mounted]** **[furnished]** coil-control valve to maintain temperature.
2. Wall-mounted, space-temperature sensor with **[temperature adjustment]** **[unit-mounted temperature adjustment]** **[adjustment on remote-control panel]** to modulate factory-**[mounted]** **[furnished]** coil-control valve to maintain temperature.

H. Electric-Coils Controls:

1. **[Factory-mounted sensor in unit discharge]** **[Remote-mounted sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to control electric coil to maintain temperature.
2. Wall-mounted, space-temperature sensor with **[temperature adjustment]** **[unit-mounted temperature adjustment]** **[adjustment on remote-control panel]** to control electric coil to maintain temperature.
3. Coil Controls: **[On/off]** **[Multiple steps]** **[Modulating SCR]** **<Insert type>**.

I. Indirect-Fired-Gas-Furnaces Controls:

1. **[Factory-mounted sensor in unit discharge]** **[Remote-mounted sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to control gas furnace burner to maintain temperature.
2. Wall-mounted, space-temperature sensor with **[temperature adjustment]** **[unit-mounted temperature adjustment]** **[adjustment on remote-control panel]** to control gas furnace burner to maintain temperature.
3. Burner Controls: **[On/off]** **[Multiple steps]** **[Modulating]** **<Insert type>**.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.7 CAPACITIES AND CHARACTERISTICS:

A. Exhaust Air:

1. Airflow: **<Insert cfm>**.
2. Face Velocity: **<Insert fpm>**.
3. Summer:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert deg. F>**.
 - b. Entering-Air Temperature, Wet Bulb: **<Insert deg. F>**.
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert deg. F>**.
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert deg. F>**.
4. Winter:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert deg. F>**.
 - b. Entering-Air Temperature, Wet Bulb: **<Insert deg. F>**.
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert deg. F>**.
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert deg. F>**.
5. Air Pressure Drop: **<Insert inches wg>**.
6. Fan Motor Size: **<Insert horsepower>**.
7. Fan Motor Electrical Characteristics:
 - a. Volts: **[120] [208] [230] <Insert value>**.
 - b. Phase: **[Single] [Three]**.
 - c. Hertz: 60.

B. Supply Air:

1. Airflow: **<Insert cfm>**.
2. Face Velocity: **<Insert fpm>**.
3. Summer:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert deg. F>**.
 - b. Entering-Air Temperature, Wet Bulb: **<Insert deg. F>**.
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert deg. F>**.
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert deg. F>**.
4. Winter:
 - a. Entering-Air Temperature, Dry Bulb: **<Insert deg. F>**.
 - b. Entering-Air Temperature, Wet Bulb: **<Insert deg. F>**.
 - c. Leaving-Air Temperature, Dry Bulb: **<Insert deg. F>**.
 - d. Leaving-Air Temperature, Wet Bulb: **<Insert deg. F>**.
5. Air Pressure Drop: **<Insert inches wg>**.
6. Fan Motor Size: **<Insert horsepower>**.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

7. Fan Motor Electrical Characteristics:

- a. Volts: [120] [208] [230] <Insert value>.
- b. Phase: [Single] [Three].
- c. Hertz: 60.

C. Wheel Drive:

- 1. Motor Size: <Insert horsepower>.
- 2. Motor Electrical Characteristics:
 - a. Volts: [120] [208] [230] <Insert value>.
 - b. Phase: [Single] [Three].
 - c. Hertz: 60.

D. Effectiveness: <Insert percent>.

E. Cooling Coil:

- 1. Fluid: [Chilled water] [Refrigerant] <Insert fluid>.
- 2. Sensible Heat-Transfer Rate: <Insert Btu/h>.
- 3. Total Heat-Transfer Rate: <Insert Btu/h>.
- 4. Entering-Air, Dry-Bulb Temperature: <Insert deg. F>.
- 5. Entering-Air, Wet-Bulb Temperature: <Insert deg. F>.
- 6. Leaving-Air, Dry-Bulb Temperature: <Insert deg. F>.
- 7. Leaving-Air, Wet-Bulb Temperature: <Insert deg. F>.
- 8. Face Area: <Insert sq. ft. >.
- 9. Maximum Face Velocity: <Insert fpm>.
- 10. Maximum Air-Side, Static-Pressure Drop: <Insert inches wg>.
- 11. Coil Type: [Continuous circuit] [Self-draining] [Cleanable].
- 12. Piping Connections: [Threaded] [Flanged], [same end] [opposite ends] of coil.
- 13. Tube Thickness: <Insert inches>.
- 14. Fin Spacing: <Insert fins per inch>.
- 15. Fin Thickness: <Insert inches>.
- 16. Number of Rows: <Insert number>.
- 17. Coil Working-Pressure Ratings: [200 psig, 325 deg. F] <Insert value>.
- 18. Fluid:
 - a. Fluid Flow: <Insert gpm>.
 - b. Maximum Fluid Pressure Drop: <Insert feet of head>.
 - c. Entering-Fluid Temperature: <Insert deg. F>.
 - d. Leaving-Fluid Temperature: <Insert deg. F>.
 - e. Tube velocity: <Insert fpm>.

F. [Hot-Water] [Steam] Coils:

- 1. Heat-Transfer Rate: <Insert Btu/h>.
- 2. Entering-Air Temperature: <Insert deg. F>.

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3. Leaving-Air Temperature: **<Insert deg. F>**.
4. Face Area: **<Insert sq. ft. >**.
5. Maximum Face Velocity: **<Insert fpm>**.
6. Maximum Air-Side, Static-Pressure Drop: **<Insert inches wg>**.
7. Coil Type: **[Continuous circuit] [Self-draining] [Cleanable]**.
8. Piping Connections: **[Threaded] [Flanged]**, **[same end] [opposite ends]** of coil.
9. Tube Thickness: **<Insert inches>**.
10. Fin Spacing: **<Insert fins per inch>**.
11. Fin Thickness: **<Insert inches>**.
12. Number of Rows: **<Insert number>**.
13. Coil Working-Pressure Ratings: **[200 psig, 325 deg. F] <Insert value>**.
14. Fluid:
 - a. Fluid Flow: **<Insert gpm>**.
 - b. Maximum Fluid Pressure Drop: **<Insert feet of head>**.
 - c. Entering-Fluid Temperature: **<Insert deg. F>**.
 - d. Leaving-Fluid Temperature: **<Insert deg. F>**.
 - e. Tube velocity: **<Insert fpm>**.
15. Steam Coils:
 - a. Heat-Transfer Rate: **<Insert Btu/h>**.
 - b. Steam Flow: **<Insert lb/h>**.
 - c. Inlet Steam Pressure: **<Insert psig>**.
 - d. Coil Working-Pressure Ratings: **[200 psig, 325 deg. F] <Insert value>**.

G. Electric Heating Coils:

1. Heat-Transfer Rate: **<Insert Btu/h>**.
2. Entering-Air Temperature: **<Insert deg. F>**.
3. Leaving-Air Temperature: **<Insert de. F>**.
4. Power Input: **<Insert kilowatts>**.
5. Volts: **[208] [230] [480] <Insert value>**.
6. Phase: **[Single] [Three]**.
7. Hertz: 60.
8. Full-Load Amperes: **<Insert value>**.
9. Maximum Overcurrent Protection: **<Insert amperage>**.
10. Capacity Control Number of Steps: **<Insert number>**.

H. Indirect-Fired Gas Furnace:

1. Heat-Transfer Rate: **<Insert Btu/h>**.
2. Entering-Air Temperature: **<Insert deg. F>**.
3. Leaving-Air Temperature: **<Insert deg. F>**.
4. Efficiency: **[80] <Insert number> percent**.
5. Fuel: **[Natural] [Propane] gas**.
6. Gas Heating Value: **<Insert Btu/cu. ft. >**.

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7. Gas Input: <Insert cfh>.
8. Power Input: <Insert kilowatts>.
9. Volts: [120] [208] [230] [480] <Insert value>.
10. Phase: [Single] [Three].
11. Hertz: 60.
12. Full-Load Amperes: <Insert value>.
13. Minimum Circuit Ampacity: <Insert value>.
14. Maximum Overcurrent Protection: <Insert amperage>.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

- A. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.
 1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
 2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
 3. Access doors and panels are specified in Section 23 33 00 – AIR DUCT ACCESSORIES.
- B. Install heat-pipe heat exchangers so supply and exhaust airstreams flow in opposite directions. Install flexible connectors on ducts to enable tilt control; make connections airtight and with slack to compensate for full tilt.
 1. Install heat exchanger with clearance space for heat-pipe coil removal.
 2. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to both sides of heat-pipe coil. Access doors and panels are specified in Section 23 33 00 – AIR DUCT ACCESSORIES.

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3. Install tilt-control components, including electronic controller, electric actuator and linkage, thermostats, and sensors.
- C. Install fixed-plate heat exchangers so supply and exhaust airstreams flow in opposite directions.
 1. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to heat exchanger. Access doors and panels are specified in Section 23 33 00 – AIR DUCT ACCESSORIES.
- D. Install gas-fired furnaces according to NFPA 54, "National Fuel Gas Code."
- E. Install floor-mounted units on 4-inch-high concrete base [**designed to withstand, without damage to equipment, seismic force required by code**].
- F. Equipment Mounting:
 1. Install air-to-air energy recovery equipment on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in [**Section 03 30 00 – CAST-IN-PLACE CONCRETE.**] [**Section 03 30 53 – MISCELLANEOUS CAST-IN-PLACE CONCRETE.**]
- G. Roof Curb: Install on roof structure or concrete base, level and secure, according to [**The NRCA "Roofing and Waterproofing Manual - Volume 4: Construction Details - Low-Slope Roofing," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts."**] [**ARI Guideline B.**] Install air-to-air energy recovery equipment on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 07 72 00 – ROOF ACCESSORIES. Secure air-to-air energy recovery equipment to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.
- H. Unit Support: Install unit level on structural [**curbs**] [**pilings**]. Coordinate wall penetrations and flashing with wall construction. Secure air-to-air energy recovery equipment to structural support with anchor bolts.
- I. Install wind and seismic restraints according to manufacturers' written instructions. [**Wind and seismically restrained vibration isolation roof-curb rails are specified in Section 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC**]
- J. Suspended Units: Suspend [**and brace**] units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC.
- K. Install units with clearances for service and maintenance.
- L. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

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- M. Pipe drains from drain pans to nearest floor drain; use ASTM B 88, Type L, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.
- N. Pipe drains from drain pans to nearest floor drain; use ASTM D 1785, Schedule 40 PVC pipe and solvent-welded fittings, same size as condensate drain connection.

3.3 CONNECTIONS:

- A. Comply with requirements for piping specified in Section 23 21 13 – HYDRONIC PIPING and Section 23 21 16 – HYDRONIC PIPING SPECIALTIES. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to unit to allow service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.
- E. **[Chilled] [and] [Hot]** Water Piping: Comply with applicable requirements in Section 23 21 13 – HYDRONIC PIPING and Section 23 21 16 – HYDRONIC PIPING SPECIALTIES. Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- F. Steam and Condensate Piping: Comply with applicable requirements in Section 23 22 13 – STEAM AND CONDENSATE HEATING PIPING and Section 23 22 16 – STEAM AND CONDENSATE HEATING PIPING SPECIALTIES. Install shutoff valve at steam coil connections, float and thermostatic trap, and union or flange at each coil return connection.
- G. Refrigerant Piping: Comply with applicable requirements in Section 23 23 00 "Refrigerant Piping."
- H. Gas Piping: Comply with requirements in [**Section 23 11 23 – FACILITY NATURAL-GAS PIPING.**] [**Section 23 11 26 – FACILITY LIQUEFIED-PETROLEUM GAS PIPING.**] Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Make connection with AGA-approved flexible connectors.
- I. Comply with requirements for ductwork specified in Section 23 31 13 – METAL DUCTS.
- J. Indirect-Fired Furnace Vent Connections: Comply with Section 23 51 23 – GAS VENTS.
- K. Install electrical devices furnished with units but not factory mounted.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3.4 FIELD QUALITY CONTROL:

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Adjust seals and purge.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 4. Set initial temperature and humidity set points.
 - 5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.5 DEMONSTRATION:

- A. **[Engage a factory-authorized service representative to train] [Train]** Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION

SECTION 23 73 33

GAS-FIRED HEATING AND VENTILATING UNITS
(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY:

- A. Section includes indirect, gas-fired heating and ventilating units.

1.4 DEFINITIONS:

- A. DDC: Direct digital control.

1.5 ACTION SUBMITTALS:

- A. Product Data: For each type and configuration of indoor, indirect, gas-fired heating and ventilating unit.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For each type and configuration of indoor, indirect, gas-fired heating and ventilating unit.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Signed, sealed, and prepared by or under the supervision of a qualified professional engineer.
2. Include plans, elevations, sections, and mounting attachment details.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
5. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
6. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
7. Include diagrams for power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS:

- A. Startup service reports.
- B. Sample Warranty: For manufacturer's special warranty.
- C. Seismic Qualification Data: Certificates, for indoor, indirect, gas-fired heating and ventilating units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.7 CLOSEOUT SUBMITTALS:

- A. Operation and Maintenance Data: For indirect-fired heating and ventilating units to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS:

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: Two set(s) for each unit.
 2. Fan Belts: One set(s) for each unit.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1.9 QUALITY ASSURANCE:

- A. Comply with NFPA 70.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.10 WARRANTY:

- A. Special Warranty: Manufacturer agrees to repair or replace components of indirect, gas-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Or Equal.
 - 3. REZNOR; Thomas & Betts Corporation, a member of ABB Group.
 - 4. Sterling HVAC Products; a Mestek company.
 - 5. York/JCI.

2.2 SYSTEM DESCRIPTION:

- A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, and hot water coil to be installed inside the building.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 UNIT CASINGS:

- A. General Fabrication Requirements for Casings:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
 2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
 3. Factory Finish for Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.
 4. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
 - a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling-unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 23 05 48 "Vibration and Seismic Controls for HVAC" when air-handling-unit frame is anchored to building structure.
 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Configuration: Horizontal unit with horizontal discharge for suspended installation.
- C. Cabinet: Galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Duct flanges at inlet and outlet.
- D. Outer Casing: 0.0598-inch-thick steel with heat-resistant, baked-enamel finish over corrosion-resistant-treated surface in color to match fan section.
- E. Inner Casing:
1. Hot water coil with copper coils and aluminum fins.
 2. Internal Insulation: Fibrous-glass duct lining, neoprene coated, comply with ASTM C 1071, Type II, applied on complete unit.
 - a. Thickness: 1-inch.
 - b. Insulation Adhesive: Comply with ASTM C 916, Type I.
 - c. Density: 1.5 lb/cu. ft.
 - d. Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.
- F. Discharge Section: Galvanized-steel assembly with two-position, motorized, parallel-blade dampers with nylon bushings.
1. Pattern: Double deflection.
 2. Leakage: Standard leakage.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- G. Discharge Section: Trapezoidal cowls with horizontal louvers.
- H. Casing Internal Insulation and Adhesive:
 - 1. Materials: ASTM C 1071.
 - 2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the heating-coil section.
 - a. Liner Adhesive: Comply with ASTM C 916, Type I.
 - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive, mechanical, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - c. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service-air velocity.
 - 3. Location and Application: Encased between outside and inside casing.
- I. Inspection and Access Panels and Access Doors:
 - 1. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
 - 2. Inspection and Access Panels:
 - a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
 - b. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
 - 3. Access Doors:
 - a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
 - b. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - c. Fabricate windows in fan section doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
 - d. Size: At least 24-inches wide by full height of unit casing.
 - 4. Service Light: 100-W vaporproof fixture with switched junction box located adjacent to door.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.4 SUPPLY-AIR FAN:

- A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings.
- B. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.
- C. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, spring isolators.
- D. Fan-Shaft Lubrication Lines: Extended to a location outside the casing.

2.5 AIR FILTERS:

- A. Comply with NFPA 90A and NFPA 90B.
- B. Disposable Panel Filters: Factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a MERV 8 according to ASHRAE 52.2.
 - 1. Thickness: 2-inches.
 - 2. Media: Interlaced glass fibers.
 - 3. Frame: Galvanized steel.

2.6 DAMPERS:

- A. Outdoor-Air and Return-Air Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. of damper area, at a differential pressure of 2-inch wg.
- B. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

2.7 UNIT CONTROL PANEL:

- A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
- B. Control Panel: Surface-mounted remote panel, with engraved plastic cover, and the following lights and switches:
 - 1. On-off-auto fan switch.
 - 2. Heat-vent-off switch.
 - 3. Supply-fan operation indicating light.
 - 4. Heating operation indicating light.

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5. Thermostat.
6. Damper position potentiometer.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.
9. Enclosure: NEMA 250.

2.8 CONTROLS:

- A. Control Devices:
 1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 2. Smoke detectors, located in supply and return air, shall stop fans when the presence of smoke is detected.
- B. Fan Control: Interlock fan to start with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.
- C. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:
 1. Minimum percent outdoor air, per schedule.
- D. Temperature Control: Operates hot water valve to maintain space-air temperature.
- E. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.
 1. Provide ASHRAE 135.1 (BACnet) communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

2.9 MOTORS:

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
 1. Enclosure: Open, dripproof or Totally enclosed, fan cooled.
 2. Enclosure Materials: Cast iron.
 3. Efficiency: Premium efficient.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of indirect-fired heating and ventilating units.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

- A. Equipment Mounting:
 - 1. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."
- B. Install controls and equipment shipped by manufacturer for field installation with indirect-fired heating and ventilating units.

3.3 CONNECTIONS:

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.
- C. Duct Connections: Connect supply and return ducts to heating and ventilating units with flexible duct connectors. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for flexible duct connectors.
- D. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

3.4 FIELD QUALITY CONTROL:

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections with the assistance of a factory-authorized service representative.
- C. Units will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 STARTUP SERVICE:

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Inspect for visible damage to burner combustion chamber.
 - b. Inspect casing insulation for integrity, moisture content, and adhesion.
 - c. Verify that clearances have been provided for servicing.
 - d. Verify that controls are connected and operable.
 - e. Verify that filters are installed.
 - f. Inspect and adjust vibration isolators and seismic restraints.
 - g. Verify bearing lubrication.
 - h. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - i. Adjust fan belts to proper alignment and tension.
 - j. Start unit according to manufacturer's written instructions.
 - 2. Complete startup sheets and attach copy with Contractor's startup report.
 - 3. Inspect and record performance of interlocks and protective devices; verify sequences.
 - 4. Operate unit for run-in period recommended by manufacturer.
 - 5. Calibrate thermostats.
 - 6. Adjust and inspect high-temperature limits.
 - 7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
 - 8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 - 9. Measure and record airflow. Plot fan volumes on fan curve.
 - 10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
 - a. High-limit heat.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

b. Alarms.

11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
12. Verify drain-pan performance.
13. Verify outdoor-air damper operation.

3.6 DEMONSTRATION:

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION

SECTION 23 81 46

GROUND SOURCE HEAT PUMP (FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections:
 - Section 03 30 00 – CAST-IN-PLACE CONCRETE
 - Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
 - Section 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC
 - Section 23 05 48.13 – VIBRATION CONTROLS FOR HVAC
 - Section 23 09 23 – DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
 - Section 23 09 93.11 – SEQUENCE OF OPERATIONS FOR HVAC DDC

1.3 SUMMARY:

- A. NFPA 70 – National Electrical Code.
- B. UL Listing and Compliance – Units are to be designed, constructed, and assembled to meet or exceed all applicable Underwriters' Laboratories' safety requirements. Units must be listed and labeled as having met UL 60335-2-40 safety standards for A2L. re-

frigerants. Installation must comply with any additional field application requirements outlined under UL 60335-2-40 or ASHRAE Standard 15 if applicable.

- C. ASHRAE 90A – “Energy Conservation in New Building Design”
- D. ANSI/ASHRAE Standard 15, Safety Standard for Refrigeration Systems
- E. ARI/ASHRAE/ISO Standard 550/590 Chilling and Heat Pump Water-Heating Packages

1.4 ACTION SUBMITTALS:

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each water-source unitary heat pump.
 - 2. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Sustainable Design Submittals
 - 1. [<Double click to insert sustainable design text for HVAC units.>](#)
 - 2. [<Double click to insert sustainable design text for unit energy performance.>](#)
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS:

- A. Section 013XX – Submittals: Procedures for submittals.
- B. Submit manufacturer’s technical product data including:
 - 1. Detailed dimensional drawings – provide unit drawings from manufacturer that indicate all necessary dimensional data including overall unit size and operating weight, unit service access panels and required clearances, ductwork connections, electrical, and plumbing connections.
 - 2. Complete unit electrical data including rated operating voltage, total unit full load amperage, minimum circuit amperage, Short-Circuit Current Rating (SCCR), maximum fuse/HACR breaker size and wiring diagrams. Wiring diagrams should

clearly differentiate between the portions of the wiring that are factory-installed and portions that are field-installed.

3. Furnished system specialties and accessories.
4. Installation instructions – indicating assembly, support details, connection requirements, and system start-up instructions.

1.6 CLOSEOUT SUBMITTALS:

- A. Section 017XX – Contract Closeout: Procedures for submittals.
- B. Include manufacturer’s descriptive literature, operating instructions, installation instructions, maintenance and trouble-shooting guides, and repair data including common repair parts.
- C. Provide a detailed equipment schedule that includes unit model and serial numbers, unit tag or identification, and location.

1.7 MAINTENANCE MATERIAL SUBMITTALS:

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. [One] <Insert number> spare heat-pump unit(s) of each size and model furnished.

1.8 WARRANTY:

- A. Section XXXXX – Contract Closeout.
- B. Warranty on Motor/Compressor: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, motors/compressors with inadequate or defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only and does not include labor for removal and reinstallation.

Standard Warranty Period: All Parts: 1 year from startup or 18 months from ship date

Extended Warranty Period: 5 year Compressor components warranty

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS:

A. WaterFurnace

- B. Section XXXXX – Materials and Equipment: Product options, Substitutions.

2.2 HEAT PUMP CHILLER EXTENDED RANGE UNITS

- A. Description: Factory assembled and tested, single packaged water-source heat pump consisting of 10-gauge welded steel frame with powder coat paint, sealed refrigerant circuit including two compressors, two refrigerants to water heat exchangers, bi-directional electronic expansion valve, reversing valve, and reverse cycle refrigeration controls. The unit and all refrigeration components shall be rated for use with R-454B refrigerant. Field conversion of refrigerants will not be allowed.
- B. Acoustical Enclosure: Provide heavy gauge galvanized steel casing with electro-statically painted finish. Provide access panels for inspection and access to internal components. Insulate panels with a minimum ½ inch thick, 15 lb./cu.ft. density, coated fiberglass insulation. All insulation must meet NFPA 90A.
- C. Refrigerant to Water Heat Exchangers: Brazed plate type heat exchangers, dual refrigerant circuits with a single water circuit, with 316 stainless steel plates and cupro-nickel braze material capable of withstanding 650 psig working pressure on the refrigerant side and 450 psig on the water side. The heat exchangers are to be insulated with ¾" inch thick, 0.27 BTU-in/hr sq.ft. thermal conductivity, expanded closed-cell foam insulation. The insulation shall be manufactured without the use of CFC's or HFC's. Provide access for cleaning.
- D. Refrigeration Components: Provide 4-way, electro-magnetically activated solenoid. refrigerant reversing valve designed for fail-safe operation in the cooling position. The solenoid coil assembly must be detachable from valve body. Provide bi-directional flow, electronic expansion valve to deliver proper superheat over the complete range of operating water temperatures. Provide bi-directional flow liquid line filter dryers on each refrigerant circuit. Provide high and low temperature cutouts, and compressor motor overload protection. Provide capability to reset compressor lockout circuit at either remote controls or circuit breaker.
- E. Compressor: Provide lead compressor as a hermetic, high efficiency, scroll type compressor with internal isolation and mounted on neoprene vibration isolators. Motor shall be permanent magnet brushless DC inverter driven for capacity modulation between 25 – 100%.)

- F. Water Piping Connections: Each chiller module shall have one set of entering and leaving water connections per water circuit to the header rack to allow for removal. The connection shall be grooved mechanical fitting constructed from cast ductile iron conforming to ASTM A-536, Grade 65-45-12 or malleable iron conforming to ASTM A-47, Grade 32510. Grooved couplings shall be rated for use with carbon steel piping conforming to ASTM F-1476, Grade A-53B/A-106B standards. Gaskets shall be Grade “E” EPDM compound conforming to ASTM D-2000 Designation 2CA615A25B24F17Z.
- G. Chiller Water Piping Header: 4-Pipe Standard (heat pump chiller)
Provide heavy gauge galvanized steel frame with electro-statically painted finish. Header rack shall be capable of being separated from the chiller module for prior installation or in the event that the chiller needs to be removed from the bank. Water piping connections to the chiller module as well as the building piping shall be grooved mechanical fittings as defined in the previous section “F”. All water piping shall be insulated with $\frac{3}{4}$ ” inch thick, 0.27 BTU-in/hr sq.ft. thermal conductivity, expanded closed-cell foam insulation. The header piping shall be isolated from each chiller module using manual and modulating butterfly type water valves. All wiring for water valve actuators and sensors shall use indexed type molded plug wiring harnesses for easy connection to the chiller module.
- H. Unit Controls:
1. Provide factory-mounted and factory-wired module-level controls for sequenced operation of compressors and reversing valves. Provide factory control panel to stage and sequence modules per BAS inputs. Dedicated power connection to non-fused, or fused rotary-type disconnect for control panel. Factory installed; DIN mounted CUBE Fuse with Class J rating wired for protection of each compressor. Low voltage, emergency stop button factory wired and mounted to control panel service door. A 24-volt class 2, minimum 75VA transformer with integral Class CC circuit breaker shall provide power to the low voltage controls. Provide safety lockout control with refrigerant high-pressure switch, refrigerant low-pressure or loss of charge switch, and water freeze protection on both the load and source heat exchangers. The lockout circuit shall be capable of being reset by either resetting the low voltage power supply or the main unit circuit breaker. Unit shall have phase loss/reversal for compressor protection.
 2. Microprocessor Control: Provide a factory installed programmable HydroLink2, microprocessor control that sequences all unit functions and modes of operation. The control shall be capable of interface with electro-mechanical temperature controls or a building automation controller using BACnet MSTP or BACnet IP communication protocols.
 3. Control Display: Provide a factory installed color touch screen HMI. The 10” HMI shall be capable of displaying:
 - a. Entering and leaving water temperatures at each brazed plate heat

- exchanger
 - b. Discharge refrigerant pressure and saturated temperature values
 - c. Suction refrigerant pressure and saturated temperature values
 - d. Superheat and subcooling values
 - e. Electrical energy consumption
 - f. Modular chiller modes and control status
 - g. Modular chiller compressor accumulated runtime.
4. Coordinate all temperature control work with the DDC Control Manufacturer, Section 159XX.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Install extended range water-source heat pumps in accordance with manufacturer's written instructions.
- B. Install units with adequate clearance from obstructions to allow for routine maintenance and servicing.
- C. Coordinate installation of units with work being performed by other trades or contractors.

3.2 CONNECTIONS:

- A. Ground Loop Water Piping: Connect supply and return piping to modular chiller bank as indicated, with unions and shutoff valves. All unit supply and return piping is to be insulated. Provide Field installed water strainers to prevent particulate debris from obstructing water flow through the water to refrigerant heat exchangers.
- B. Electrical: Install all electrical devices furnished but not specified to be factory mounted. Verify that unit is properly grounded and that wiring connections are in accordance with manufacturer's written documentation.

3.3 FIELD QUALITY CONTROL:

- A. General: Start-up modular chillers in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements with Project Manager on site to witness test. Document all controls settings and configurations. Replace damaged or malfunctioning control components.

3.4 DEMONSTRATION:

- A. Provide the services of a factory-authorized representative, for up to four hours, to instruct the Owner's personnel as specified:
 - 1. Train Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance.
 - 2. Review data in the maintenance manuals specified in Section 1.6.
 - 3. Schedule training with Owner, through Project Manager, with at least 21 days' advance notice.

END OF SECTION

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

SECTION 23 82 19

FAN COIL UNITS

(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 – HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contracts, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of the Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections:

Section 01 78 23 – OPERATION AND MAINTENANCE DATA

Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

Section 23 05 48 – VIBRATION AND SEISMIC CONTROL FOR HVAC PIPING AND EQUIPMENT

Section 23 06 16 – HVAC EQUIPMENT INSULATION

Section 23 09 23 – DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

Section 23 09 93.11 – SEQUENCE OF OPERATIONS FOR HVAC DDC

Section 23 33 00 – AIR DUCT ACCESSORIES

Section 23 62 00 – PACKAGED COMPRESSOR AND CONDENSER UNITS

Section 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

Section 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

1.3 SUMMARY:

A. Section Includes:

1. Ductless fan coil units and accessories.
2. Ducted fan coil units and accessories.

1.4 ACTION SUBMITTALS:

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

1. [<Double click to insert sustainable design text for HVAC units.>](#)

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification: For each type of fan coil unit indicated.

1.5 INFORMATIONAL SUBMITTALS:

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which fan coil units will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.

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- d. Sprinklers.
 - e. Access panels.
 - f. <Insert item>.
 - 6. Perimeter moldings.
 - B. Seismic Qualification Certificates: For fan coil units, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - C. Field quality-control reports.
 - D. Sample Warranty: For special warranty.
- 1.6 CLOSEOUT SUBMITTALS:
- A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 01 78 23 – OPERATION AND MAINTENANCE DATA, include the following:
 - a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.
- 1.7 MAINTENANCE MATERIAL SUBMITTALS:
- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fan Coil Unit Filters: Furnish <Insert number> spare filters for each filter installed.
 - 2. Fan Belts: Furnish <Insert number> spare fan belts for each unit installed.
- 1.8 QUALITY ASSURANCE:
- A. Comply with NFPA 70.:
 - B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

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- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.9 COORDINATION:

- A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.10 WARRANTY:

- A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Compressor failure.
 - b. Condenser coil leak.
 - 2. Warranty Period: **[Four]** **[Five]** **[10]** **<Insert number>** years from date of Substantial Completion.
 - 3. Warranty Period (Compressor Only): **[Five]** **[10]** **<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION:

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 DUCTLESS FAN COIL UNITS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Fan Coil Unit Configurations: **[Row]** **[Face]** split.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Number of Heating Coils: [**One**] <Insert number> with two-pipe system.
 2. Number of Cooling Coils: [**One**] [**Three**] with [**two**][**four**]-pipe system.
- C. Coil Section Insulation: [**1/2-inch-**] [**1-inch-**] <Insert dimension> thick, [**coated glass fiber**] [**foil-covered, closed-cell foam**] [**matte-finish, closed-cell foam**] complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Coil Section Insulation: Insulate coil section according to Section 23 06 16 – HVAC EQUIPMENT INSULATION.
1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- E. [**Main and Auxiliary**] Drain Pans: [**Plastic**] [**Stainless steel**] [**Insulated galvanized steel with plastic liner**]. Fabricate pans and drain connections to comply with ASHRAE 62.1. [**Drain pans shall be removable.**]
- F. Chassis: Galvanized steel where exposed to moisture [, **with baked-enamel finish and removable access panel**] [, **with powder-coat finish and removable access panel**]. Floor-mounting units shall have leveling screws.
- G. Cabinet: Steel with [**factory prime coating, ready for field painting**] [**baked-enamel finish in manufacturer's standard paint color as selected by Architect**] [**baked-enamel finish in manufacturer's custom paint color as selected by Architect**].
1. Vertical Unit Front Panels: Removable, steel, with [**integral stamped**] [**polyethylene**] [**steel**] discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
 2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with [**integral stamped**] [**cast-aluminum**] discharge grilles.
 3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from manufacturer's [**standard**] [**custom**] colors. Return grille shall provide maintenance access to fan coil unit.
 4. Steel recessing flanges for recessing fan coil units into ceiling or wall.
- H. Outdoor-Air Wall Box: Minimum 0.1265-inch-thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Louver Configuration: [**Horizontal**] [**Vertical**], rain-resistant louver.
 2. Louver Material: [**Aluminum**] [**Steel**].
 3. Bird Screen: 1/2-inch mesh screen on interior side of louver.
 4. Decorative Grille: On outside of intake.
 5. Finish: [**Anodized aluminum**] [**Baked enamel**], color as selected by Architect from manufacturer's [**standard**] [**custom**] colors.
- I. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with [**electronic**] [**pneumatic**], [**two-position**] [**modulating**] actuators.
- J. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
1. MERV Rating: [**6**] [**13**] <Insert number> when tested according to ASHRAE 52.2.
 2. Washable Foam: 70 percent arrestance and MERV [**3**].
 3. Glass Fiber Treated with Adhesive: 80 percent arrestance and MERV [**5**].
 4. Pleated Cotton-Polyester Media: 90 percent arrestance and MERV [**7**].
- K. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg. F. Include manual air vent and drain valve.
- L. Indoor Refrigerant Coils: [**Copper**] [**Stainless-steel**] tube, with mechanically bonded [**aluminum**] [**stainless-steel**] fins spaced no closer than 0.1 inch and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.
- M. Steam Coils: Copper [**distributing**] tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 75 psig.
- N. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
- O. Fan and Motor Board: Removable.
1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
 3. Wiring Termination: Connect motor to chassis wiring with plug connection.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- P. Factory, Hydronic Piping Package: [ASTM B 88, Type L] [ASTM B 88, Type M] copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
1. [Two][Three]-way, [two-position] [modulating] control valve for dual-temperature coil.
 2. [Two][Three]-way, [two-position] [modulating] control valve for chilled-water coil.
 3. [Two][Three]-way, [two-position] [modulating] control valve for hot-water heating coil.
 4. [Two][Three]-way [two-position] [modulating] control valve for hot-water reheat coil.
 5. Hose Kits: Minimum 400-psig working pressure and operating temperatures from 33 to 211 deg. F. Tag hose kits to equipment designations.
 - a. Length: [24 inches] [36 inches] <Insert dimension>.
 - b. Minimum Diameter: Equal to fan coil unit connection size.
 6. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
 7. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig working pressure, 250 deg. F maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
 8. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig working pressure at 250 deg. F; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig.
 9. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
 10. Wrought-Copper Unions: ASME B16.22.
 11. Risers: [ASTM B 88, Type L] [ASTM B 88, Type M] copper pipe with hose and ball valve for system flushing.
- Q. Control devices and operational sequences are specified in Section 23 09 23 – DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC and Section 23 09 93.11 – SEQUENCE OF OPERATIONS FOR HVAC DDC.
- R. Basic Unit Controls:
1. Control voltage transformer.
 2. [Wall-mounting] [Unit-mounted] thermostat with the following features:
 - a. Heat-cool-off switch.
 - b. Fan on-auto switch.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- c. Fan-speed switch.
 - d. **[Manual]** **[Automatic]** changeover.
 - e. Adjustable deadband.
 - f. **[Concealed]** **[Exposed]** set point.
 - g. **[Concealed]** **[Exposed]** indication.
 - h. **[Degree F]** **[Degree C]** indication.
3. **[Wall-mounting]** **[Unit-mounted]** humidistat.
- a. **[Concealed]** **[Exposed]** set point.
 - b. **[Concealed]** **[Exposed]** indication.
4. **[Wall-mounting]** **[Unit-mounted]** temperature sensor.
5. Unoccupied-period-override push button.
6. Data entry and access port.
- a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
 - b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
- S. **[DDC]** Terminal Controller:
- 1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 - 2. Unoccupied-Period-Override Operation: **[Two]** **<Insert number>** hours.
 - 3. Unit Supply-Air Fan Operation:
 - a. Occupied Periods: Fan runs continuously.
 - b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
 - 4. Hydronic-Cooling-Coil Operation:
 - a. Occupied Periods: **[Open]** **[Modulate]** control valve to maintain room temperature.
 - b. Unoccupied Periods: Close control valve.
 - 5. Refrigerant-Coil Operation:
 - a. Occupied Periods: Start compressor to maintain room temperature or humidistat set point.
 - b. Unoccupied Periods: Stop compressor cooling and cycle compressor for heating to maintain setback temperature.
 - 6. **[Supplemental]** Heating-Coil Operation:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Occupied Periods: [**Open control valve**] [**Modulate control valve**] [**Energize electric-resistance coil**] to provide heating if room temperature falls below thermostat set point.
 - b. Unoccupied Periods: Start fan and [**open control valve**] [**modulate control valve**] [**energize electric-resistance coil**] if room temperature falls below setback temperature.
 - c. Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below [**25 deg. F**] <**Insert temperature**>.
7. Dual-Temperature Hydronic-Coil Operation:
- a. Occupied Periods: When chilled water is available, [**open**] [**modulate**] control valve if room temperature exceeds thermostat set point. When hot water is available, open control valve if temperature falls below thermostat set point.
 - b. Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, [**open**] [**modulate**] control valve if room temperature falls below thermostat setback temperature.
8. Reheat-Coil Operation:
- a. Humidity Control for Occupied Periods:
 - 1) Humidistat [**opens control valve**] [**modulates control valve**] [**energizes electric-resistance coil**] to provide heating. As space temperature rises above set point, cooling-coil valve [**opens**] [**modulates**] to maintain room temperature.
 - b. Humidity Control for Unoccupied Periods: [**Close control valve**] [**De-energize**].
 - c. Occupied Periods:
 - 1) Heating Operations: [**Open control valve**] [**Modulate control valve**] [**Energize electric-resistance coil**] to provide heating if room temperature falls below thermostat set point.
 - 2) Humidity-Control Operations: Humidistat [**opens control valve**] [**modulates control valve**] [**energizes electric-resistance coil**] to provide heating. As space temperature rises above set point, cooling-coil valve [**opens**] [**modulates**] to maintain room temperature.
 - d. Unoccupied Periods: Start fan and [**open control valve**] [**modulate control valve**] [**energize electric-resistance coil**] if room temperature falls below setback temperature. Humidity control is not available.
9. Outdoor-Air Damper Operation:
- a. Occupied Periods: Open damper to fixed position for [**25**] <**Insert number**> percent outdoor air.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- b. Unoccupied periods: Close damper.
10. Outdoor-Air Damper Operation:
- a. Occupied Periods:
 - 1) Outdoor-Air Temperature below Room Temperature: If room temperature is above thermostat set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below thermostat set point, position damper to fixed minimum position.
 - 2) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for [25] <Insert number> percent outdoor air.
 - b. Unoccupied Periods: Close damper.
11. Outdoor-Air Damper Operation (Enthalpy Based):
- a. Occupied Periods:
 - 1) Outdoor-Air Enthalpy below Room Enthalpy: If room temperature is above room-temperature set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum position for [25] <Insert number> percent outdoor air.
 - 2) Outdoor-Air Enthalpy above Room Enthalpy: Position damper to fixed minimum position for [25] <Insert number> percent outdoor air.
 - b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
12. Controller shall have volatile-memory backup.
- T. Interface with DDC System for HVAC Requirements:
- 1. Interface relay for scheduled operation.
 - 2. Interface relay to provide indication of fault at the central workstation.
 - 3. Provide [BACnet] [or] [LonWorks] interface for central DDC system for HVAC workstation for the following functions:
 - a. Adjust set points.
 - b. Fan coil unit start, stop, and operating status.
 - c. Data inquiry, including [outdoor-air damper position,] supply- and room-air temperature [and humidity].
 - d. Occupied and unoccupied schedules.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

U. Electrical Connection: Factory wire motors and controls for a single electrical connection.

V. Capacities and Characteristics:

1. Fan:

- a. Airflow: **<Insert cfm>**.
- b. External Static Pressure: **<Insert inches wg>**.
- c. Fan Speed: **<Insert rpm>**.
- d. Motor Speed: **<Insert rpm>**.
- e. Motor Horsepower: **<Insert horsepower>**.
- f. Drive: **[Direct] [Belt]**.

2. Cooling Capacity:

- a. Total: **<Insert Btu/h>**.
- b. Sensible: **<Insert Btu/h>**.
- c. Entering-Air Dry-Bulb Temperature: **<Insert deg. F>**.
- d. Entering-Air Wet-Bulb Temperature: **<Insert deg. F>**.

3. Chilled-Water Coil:

- a. Water Flow: **<Insert gpm>**.
- b. Water-Side Pressure Loss: **<Insert feet wg>**.
- c. Entering-Water Temperature: **<Insert deg. F>**.
- d. Air-Side Pressure Drop: **<Insert inches wg>**.

4. Refrigerant Coil:

- a. Air-Side Pressure Loss: **<Insert inches wg>**.
- b. Suction Temperature: **<Insert deg. F>**.

5. Heating Capacity:

- a. Output: **<Insert Btu/h>**.
- b. Entering-Air Temperature: **<Insert deg. F>**.
- c. Air-Temperature Rise: **<Insert deg. F>**.

6. Hot-Water Heating Coil:

- a. Water Flow: **<Insert gpm>**.
- b. Water-Side Pressure Loss: **<Insert feet wg>**.
- c. Air-Side Pressure Drop: **<Insert inches wg>**.
- d. Entering-Water Temperature: **<Insert deg. F>**.

7. Steam Heating Coil:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Inlet Steam Pressure: **<Insert psig>**.
 - b. Condensing Capacity: **<Insert lb/h>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg>**.
8. Electric-Resistance Heating Coil:
 - a. Capacity: **<Insert kilowatts>**.
 - b. Number of Steps: **<Indicate number>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg>**.
9. Reheat Capacity:
 - a. Output: **<Insert Btu/h>**.
 - b. Entering-Air Temperature: **<Insert deg. F>**.
 - c. Air-Temperature Rise: **<Insert deg. F>**.
10. Filters:
 - a. Face Area: **<Insert sq. ft. >**.
 - b. Thickness: **[1 inch] [2 inches] <Insert dimension>**.
11. Electrical Characteristics for Single-Point Connection:
 - a. Voltage/Phase/Hertz: **<Insert values>**.
 - b. Full-Load Amperes: **<Insert value>**.
 - c. Maximum Circuit Amperes: **<Insert value>**.
 - d. Maximum Overcurrent Protection: **<Insert amperage>**.

2.3 DUCTED FAN COIL UNITS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Fan Coil Unit Configurations: **[Row] [Face]** split.
 1. Number of Heating Coils: **[One]** with two-pipe system.
 2. Number of Cooling Coils: **[One] [Three]** with **[two][four]**-pipe system.
- C. Coil Section Insulation: **[1/2-inch-] [1-inch-] <Insert dimension>** thick, **[coated] [foil-faced]** glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
 1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- D. Coil Section Insulation: Insulate coil section according to Section 23 06 16 – HVAC EQUIPMENT INSULATION.
 - 1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
 - 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- E. **[Main and Auxiliary] Drain Pans: [Plastic] [Stainless steel] [Insulated galvanized steel with plastic liner]**. Fabricate pans and drain connections to comply with ASHRAE 62.1.
- F. Chassis: Galvanized steel where exposed to moisture [, **with baked-enamel finish and removable access panel**] [, **with powder-coat finish and removable access panel**]. Floor-mounting units shall have leveling screws.
- G. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
 - 1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis [**with mill-finish, aluminum, double-deflection grille**].
 - 2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
 - 3. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.
 - 4. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.
- H. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
- I. MERV Rating: **[6] [13] <Insert number>** when tested according to ASHRAE 52.2.
 - 1. Washable Foam: 70 percent arrestance and MERV [**3**].
 - 2. Glass Fiber Treated with Adhesive: 80 percent arrestance and MERV [**5**].
 - 3. Pleated Cotton-Polyester Media: 90 percent arrestance and MERV [**7**].
- J. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg. F. Include manual air vent and drain.
- K. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.
- L. Steam Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 75 psig.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- M. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
- N. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
 - 1. Motors: Comply with requirements in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC.
- O. Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
 - 1. Motors: Comply with requirements in Section 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- P. Factory, Hydronic Piping Package: [ASTM B 88, Type L] [ASTM B 88, Type M] copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
 - 1. [Two][Three]-way, [two-position] [modulating] control valve for chilled-water coil.
 - 2. [Two][Three]-way, [two-position] [modulating] control valve for heating coil.
 - 3. [Two][Three]-way, [two-position] [modulating] control valve for dual-temperature coil.
 - 4. [Two][Three]-way, [two-position] [modulating] control valve for reheat coil.
 - 5. Hose Kits: Minimum 400-psig working pressure and operating temperatures from 33 to 211 deg. F. Tag hose kits to equipment designations.
 - a. Length: [24 inches] [36 inches] <Insert dimension>.
 - b. Minimum Diameter: Equal to fan coil unit connection size.
 - 6. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
 - 7. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig working pressure, 250 deg. F maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
 - 8. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig working pressure at 250 deg. F; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

9. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
 10. Wrought-Copper Unions: ASME B16.22.
- Q. Remote condensing units are specified in Section 23 62 00 – PACKAGED COMPRESSOR AND CONDENSER UNITS.
- R. Control devices and operational sequence are specified in Section 23 05 48 – VIBRATION AND SEISMIC CONTROL FOR HVAC PIPING AND EQUIPMENT.
- S. Basic Unit Controls:
1. Control voltage transformer.
 2. [Wall-mounting] [Unit-mounted] thermostat with the following features.
 - a. Heat-cool-off switch.
 - b. Fan on-auto switch.
 - c. Fan-speed switch.
 - d. [Manual] [Automatic] changeover.
 - e. Adjustable deadband.
 - f. [Concealed] [Exposed] set point.
 - g. [Concealed] [Exposed] indication.
 - h. [Degree F] [Degree C] indication.
 3. [Wall-mounting] [Unit-mounted] humidistat.
 - a. [Concealed] [Exposed] set point.
 - b. [Concealed] [Exposed] indication.
 4. [Wall-mounting] [Unit-mounted] temperature sensor.
 5. Unoccupied-period-override push button.
 6. Data entry and access port.
 - a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
 - b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
- T. [DDC] Terminal Controller:
1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 2. Unoccupied-Period-Override Operation: [Two] <Insert number> hours.
 3. Unit Supply-Air Fan Operation:
 - a. Occupied Periods: Fan runs continuously.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
- 4. Hydronic-Cooling-Coil Operation:
 - a. Occupied Periods: [**Open**] [**Modulate**] control valve to maintain room temperature.
 - b. Unoccupied Periods: Close control valve.
- 5. Refrigerant-Coil Operation:
 - a. Occupied Periods: Start compressor to maintain room temperature or humidistat set point.
 - b. Unoccupied Periods: Stop compressor cooling and cycle compressor for heating to maintain setback temperature.
- 6. [**Supplemental**] Heating-Coil Operation:
 - a. Occupied Periods: [**Open control valve**] [**Modulate control valve**] [**Energize electric-resistance coil**] to provide heating if room temperature falls below thermostat set point.
 - b. Unoccupied Periods: Start fan and [**open control valve**] [**modulate control valve**] [**energize electric-resistance coil**] if room temperature falls below setback temperature.
 - c. Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below [**25 deg. F**] <**Insert temperature**>.
- 7. Dual-Temperature Hydronic-Coil Operation:
 - a. Occupied Periods: When chilled water is available, [**open**] [**modulate**] control valve if room temperature exceeds thermostat set point. When hot water is available, [**open**] [**modulate**] control valve if temperature falls below thermostat set point.
 - b. Unoccupied Periods: When chilled water is available, close valve. When hot water is available, [**open**] [**modulate**] control valve if room temperature falls below thermostat setback temperature.
- 8. Reheat-Coil Operation:
 - a. Humidity Control for Occupied Periods:
 - 1) Humidistat [**opens control valve**] [**modulates control valve**] [**energizes electric-resistance coil**] to provide heating. As room temperature rises above set point, cooling-coil valve [**opens**] [**modulates**] to maintain room temperature.
 - b. Humidity Control for Unoccupied Periods: [**Close control valve**] [**De-energize**].
 - c. Occupied Periods:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- 1) Heating Operations: [**Open control valve**] [**Modulate control valve**] [**Energize electric-resistance coil**] to provide heating if room temperature falls below thermostat set point.
 - 2) Humidity-Control Operations: Humidistat [**opens control valve**] [**modulates control valve**] [**energizes electric-resistance coil**] to provide heating. As room temperature rises above set point, cooling-coil valve [**opens**] [**modulates**] to maintain room temperature.
 - d. Unoccupied Periods: Start fan and [**open control valve**] [**modulate control valve**] [**energize electric-resistance coil**] if room temperature falls below setback temperature. Humidity control is not available.
9. Outdoor-Air Damper Operation:
- a. Occupied Periods: Open damper to fixed position for [25] **<Insert number>** percent outdoor air.
 - b. Unoccupied Periods: Close damper.
10. Outdoor-Air Damper Operation:
- a. Occupied Periods:
 - 1) Outdoor-Air Temperature below Room Temperature: If room temperature is above room-temperature set point, modulate outdoor-and return-air dampers to maintain room temperature set point (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum setting.
 - 2) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for [25] **<Insert number>** percent outdoor air.
 - b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
11. Outdoor-Air Damper Operation (Enthalpy Based):
- a. Occupied Periods:
 - 1) Outdoor-Air Enthalpy below Room Enthalpy: If room temperature is above room-temperature set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum position for [25] **<Insert number>** percent outdoor air.
 - 2) Outdoor-Air Enthalpy above Room Enthalpy: Position damper to fixed minimum position for [25] **<Insert number>** percent outdoor air.
 - b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

12. Controller shall have volatile-memory backup.

U. Interface with DDC System for HVAC Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation.
3. Provide [**BACnet**] [**or**] [**LonWorks**] interface for central DDC system for HVAC workstation for the following functions:
 - a. Adjust set points.
 - b. Fan coil unit start, stop, and operating status.
 - c. Data inquiry, including [**outdoor-air damper position,**] **supply-** and room-air temperature [**and humidity**].
 - d. Occupied and unoccupied schedules.

V. Electrical Connection: Factory wire motors and controls for a single electrical connection.

W. Capacities and Characteristics:

1. Fan:
 - a. Airflow: **<Insert cfm>**.
 - b. Static Pressure: **<Insert inches wg>**.
 - c. Fan Speed: **<Insert rpm>**.
 - d. Motor Speed: **<Insert rpm>**.
 - e. Motor Horsepower: **<Insert horsepower>**.
 - f. Drive: [**Direct**] [**Belt**].
2. Cooling Capacity:
 - a. Total: **<Insert Btu/h>**.
 - b. Sensible: **<Insert Btu/h>**.
 - c. Entering-Air Dry-Bulb Temperature: **<Insert deg. F>**.
 - d. Entering-Air Wet-Bulb Temperature: **<Insert deg. F>**.
3. Chilled-Water Coil:
 - a. Water Flow: **<Insert gpm>**.
 - b. Water-Side Pressure Loss: **<Insert feet wg>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg>**.
 - d. Entering-Water Temperature: **<Insert deg F>**.
4. Refrigerant Coil:
 - a. Air-Side Pressure Loss: **<Insert inches wg>**.
 - b. Suction Temperature: **<Insert deg. F>**.

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5. Heating Capacity:
 - a. Output: **<Insert Btu/h>**.
 - b. Entering-Air Temperature: **<Insert deg. F>**.
 - c. Air-Temperature Rise: **<Insert deg. F>**.
6. Hot-Water Heating Coil:
 - a. Water Flow: **<Insert gpm>**.
 - b. Water-Side Pressure Loss: **<Insert feet wg>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg>**.
 - d. Entering-Water Temperature: **<Insert deg. F>**.
7. Steam Heating Coil:
 - a. Inlet Steam Pressure: **<Insert psig>**.
 - b. Condensing Capacity: **<Insert lb./h>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg>**.
8. Electric-Resistance Heating Coil:
 - a. Capacity: **<Insert kilowatts>**.
 - b. Number of Steps: **<Insert number>**.
 - c. Air-Side Pressure Drop: **<Insert inches wg>**.
9. Reheat Capacity:
 - a. Output: **<Insert Btu/h>**.
 - b. Entering-Air Temperature: **<Insert deg. F>**.
 - c. Air-Temperature Rise: **<Insert deg. F>**.
10. Filters:
 - a. Face Area: **<Insert sq. ft. >**.
 - b. Thickness: **[1 inch] [2 inches] <Insert dimension>**.
11. Electrical Characteristics for Single-Point Connection:
 - a. Voltage/Phase/Hertz: **<Insert values>**.
 - b. Full-Load Amperes: **<Insert values>**.
 - c. Maximum Circuit Amperes: **<Insert values>**.
 - d. Maximum Overcurrent Protection: **<Insert amperage>**.

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PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

- A. Install fan coil units level and plumb.
- B. Install fan coil units to comply with NFPA 90A.
- C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 23 05 48 – VIBRATION AND SEISMIC CONTROL FOR HVAC PIPING AND EQUIPMENT.
- D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices [48 inches] [60 inches] <Insert dimension> above finished floor.
- E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS:

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Install piping adjacent to machine to allow service and maintenance.
 - 2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
 - 3. Connect condensate drain to indirect waste.
 - a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.
- B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 23 33 00 – AIR DUCT ACCESSORIES. Comply with safety requirements in UL 1995 for duct connections.

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- C. Ground equipment according to Section 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- D. Connect wiring according to Section 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.4 FIELD QUALITY CONTROL:

- A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections [**with the assistance of a factory-authorized service representative**]:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.5 ADJUSTING:

- A. Adjust initial temperature and humidity set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [**two**] <**Insert number**> visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION:

- A. [**Engage a factory-authorized service representative to train**] [**Train**] Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION

SECTION 23 82 39

UNIT HEATERS

(FILED SUB-BID REQUIRED AS PART OF SECTION 23 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-Bid Requirements: As provided under Section 23 00 01 - HVAC SUB-BID REQUIREMENTS, and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY:

- A. Section includes cabinet unit heaters with centrifugal fans and [hot-water] [steam] [electric-resistance heating] coils, propeller unit heaters with [hot-water] [steam] [electric-resistance heating] coils, and wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.4 DEFINITIONS:

- A. CWP: Cold working pressure.
- B. DDC: Direct digital control.
- C. PTFE: Polytetrafluoroethylene plastic.
- D. TFE: Tetrafluoroethylene plastic.

1.5 ACTION SUBMITTALS:

- A. Product Data: For each type of product.

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1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals:

1. For cabinet unit heaters - [<Double click to insert sustainable design text for HVAC units.>](#)
2. For propeller unit heaters - [<Double click to insert sustainable design text for HVAC units.>](#)
3. For wall and ceiling unit heaters - [<Double click to insert sustainable design text for HVAC units.>](#)

C. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.
5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
6. Indicate location and arrangement of piping valves and specialties.
7. Indicate location and arrangement of integral controls.
8. Wiring Diagrams: Power, signal, and control wiring.

D. Samples: For each exposed product and for each color and texture specified.

E. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

F. Samples for Verification: Finish colors for each type of cabinet unit heater indicated with factory-applied color finishes.

1.6 INFORMATIONAL SUBMITTALS:

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which cabinet unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

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- a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. **<Insert item>**.
 6. Perimeter moldings for exposed or partially exposed cabinets.
 - B. Seismic Qualification Data: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Section 23 05 48 "Vibration and Seismic Controls for HVAC." Include the following:
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Include detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - C. Field quality-control reports.
- 1.7 CLOSEOUT SUBMITTALS:
- A. Operation and Maintenance Data: For cabinet unit heaters, propeller unit heaters, wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.
- 1.8 MAINTENANCE MATERIAL SUBMITTALS:
- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Cabinet Unit-Heater Filters: Furnish **[one]** **<Insert number>** spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. For cabinet unit heaters - [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. For propeller unit heaters - [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- C. For wall and ceiling unit heaters - [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2.2 DESCRIPTION – CABINET UNIT HEATERS:

- A. Factory-assembled and -tested unit complying with AHRI 440.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 2021.

2.3 PERFORMANCE REQUIREMENTS:

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- C. Seismic Performance: Cabinet unit heaters shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7] **<Insert requirement>**.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified [**and the unit will be fully operational after the seismic event**]."

2.4 COIL SECTION INSULATION:

- A. Insulation Materials: ASTM C 1071; surfaces exposed to airstream shall have [**aluminum-foil facing**] [**erosion-resistant coating**] to prevent erosion of glass fibers.
 - 1. Thickness: [**1/2-inch**] [**1-inch**] [**1-1/2-inches**].
 - 2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
 - 3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - 4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
 - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Insulation Materials: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.

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1. Thickness: **[3/8-inch]** **[1/2-inch]** **[3/4-inch]** **[1-inch]**.
2. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.5 CABINETS:

- A. Material: Steel with **[factory prime coating, ready for field painting]** **[baked-enamel finish with manufacturer's standard paint, in color selected by Architect]** **[baked-enamel finish with manufacturer's custom paint, in color selected by Architect]**.

1. Vertical Unit, Exposed Front Panels: Minimum **[0.0528-inch-]** **[0.0677-inch-]** thick **[galvanized]** sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
2. Horizontal Unit, Exposed Bottom Panels: Minimum **[0.0528-inch-]** **[0.0677-inch-]** thick **[galvanized]** sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
3. Recessed Flanges: Steel, finished to match cabinet.
4. Control Access Door: Key operated.
5. Base: Minimum 0.0528-inch-thick steel, finished to match cabinet, **[4-inches]** **[6-inches]** **<Insert dimension>** high with leveling bolts.
6. Extended Piping Compartment: **[8-inch-]** **<Insert dimension>** wide piping end pocket.
7. False Back: Minimum 0.0428-inch-thick steel, finished to match cabinet.
8. Outdoor-Air Wall Box: Minimum 0.1265-inch-thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen; aluminum louver with **[anodized]** **[baked-enamel]** finish in color selected by Architect from manufacturer's **[standard]** **[custom]** colors.
 - a. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with **[manual]** **[electronic]** **[pneumatic]**, two-position actuators.

2.6 FILTERS:

- A. Minimum Arrestance: And a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Washable Foam: 70 percent arrestance and MERV 3.
 2. Glass Fiber Treated with Adhesive: 80 percent arrestance and MERV 5.
 3. Pleated: 90 percent arrestance and MERV 7.

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2.7 COILS:

- A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.
- B. Steam Coil: Copper [**distributing**] tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 75 psig.
- C. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

2.8 CONTROLS:

- A. Fan and Motor Board: Removable.
 - 1. Fan: Forward curved, [**high static,**] double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
 - 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
 - 3. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- B. Factory, Hot-Water Piping Package: [**ASTM B 88, Type L**] [**ASTM B 88, Type M**] copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
 - 1. [**Two**] [**Three**]-way, [**two-position**] [**modulating**] control valve. [**Three-way valve packages shall include bypass line with manually adjustable balance device.**]
 - 2. Hose Kits: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.
 - a. Length: [**24-inches**] [**36-inches**] <**Insert dimension**>.
 - b. Minimum Diameter: Equal to cabinet unit-heater connection size.
 - 3. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
 - 4. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.

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5. Automatic Flow-Control Valve: Brass or ferrous-metal body, 300-psig working pressure at 250 deg F, with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow within plus or minus 10 percent of differential pressure range of 2 to 80 psig.
 6. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 threaded pipe and full-port ball valve in strainer drain connection.
 7. Wrought-Copper Unions: ASME B16.22.
- C. Control devices and operational sequences are specified in Section 23 09 23 "Direct Digital Control (DDC) System for HVAC" and Section 23 09 93.11 "Sequence of Operations for HVAC DDC."
- D. Basic Unit Controls:
1. Control voltage transformer.
 2. **[Wall]** **[Unit]**-mounted thermostat with the following features:
 - a. Heat-off switch.
 - b. Fan on-auto switch.
 - c. Manual fan-speed switch.
 - d. Adjustable deadband.
 - e. **[Concealed]** **[Exposed]** set point.
 - f. **[Concealed]** **[Exposed]** indication.
 - g. Deg F indication.
 3. **[Wall]** **[Unit]**-mounted temperature sensor.
 4. Unoccupied period override push button.
 5. Data entry and access port.
 - a. Input data includes room temperature and occupied and unoccupied periods.
 - b. Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.
- E. **[DDC] Terminal Controller:**
1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 2. Unoccupied Period Override: **[Two]** **<Insert number>** hours.
 3. Unit Supply-Air Fan Operations:
 - a. Occupied Periods: Fan runs continuously.
 - b. Unoccupied Periods: Fan cycles to maintain setback room temperature.
 4. Heating-Coil Operations:

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- a. Occupied Periods: [**Open control valve**] [**Modulate control valve**] [**Energize electric-resistance coil**] to provide heating if room temperature falls below thermostat set point.
 - b. Unoccupied Periods: Start fan and [**open control valve**] [**modulate control valve**] [**energize electric-resistance coil**] if room temperature falls below setback temperature.
5. Outdoor-Air Damper Operation:
- a. Occupied Periods: Open dampers. Delay damper opening if room temperature is more than three degrees below set point.
 - b. Unoccupied Periods: Close damper.
6. Controller shall have volatile-memory backup.
- F. Interface with DDC System for HVAC Requirements:
1. Interface relay for scheduled operation.
 2. Interface relay to provide indication of fault at central workstation.
 3. Interface shall be [**BAC-net**] [**or**] [**LonWorks**] compatible for central DDC system for HVAC workstation and include the following functions:
 - a. Adjust set points.
 - b. Cabinet unit-heater start, stop, and operating status.
 - c. Data inquiry, including [**outdoor-air damper position and**] supply-air and room-air temperature.
 - d. Occupied and unoccupied schedules.
- G. Electrical Connection: Factory-wired motors and controls for a single field connection.

2.9 CAPACITIES AND CHARACTERISTICS:

A. Cabinet:

1. Vertical, Surface Mounted: Upflow.
 - a. Top: [**Flat**] [**Sloped**] [**Flat or sloped**].
 - b. Air Inlet: [**Open bottom**] [**Front, punched louver**] [**Front, extruded-aluminum bar grille**].
 - c. Air Outlet: [**Front**] [**Top**] [**Front or top**], [**quad louver**] [**punched louver**] [**extruded-aluminum bar grille**].
2. Vertical, Surface Mounted: Downflow.
 - a. Top: [**Flat**] [**Sloped**] [**Flat or sloped**].
 - b. Air Inlet: [**Front**] [**Top**] [**Front or top**], [**punched louver**] [**extruded-aluminum bar grille**].

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- c. Air Outlet: Front, [**quad louver**] [**punched louver**] [**extruded-aluminum bar grille**].
- 3. Vertical, Semirecessed: Upflow.
 - a. Air Inlet: [**Open bottom**] [**Front, punched louver**] [**Front, extruded-aluminum bar grille**].
 - b. Air Outlet: [**Front**] [**Top**] [**Front or top**], [**quad louver**] [**punched louver**] [**extruded-aluminum bar grille**].
- 4. Vertical, Semirecessed: Downflow.
 - a. Air Inlet: [**Front**] [**Top**] [**Front or top**], [**punched louver**] [**extruded-aluminum bar grille**].
 - b. Air Outlet: Front, [**quad louver**] [**punched louver**] [**extruded-aluminum bar grille**].
- 5. Vertical, Fully Recessed: [**Upflow**] [**Downflow**].
 - a. Air Inlet: [**Front**] [**Duct connection**], [**punched louver**] [**extruded-aluminum bar grille**].
 - b. Air Outlet: [**Front**] [**Duct connection**], [**quad louver**] [**punched louver**] [**extruded-aluminum bar grille**].
- 6. Horizontal, Surface Mounted:
 - a. Air Inlet: [**Bottom**] [**Front**] [**Bottom or front**], [**punched louver**] [**extruded-aluminum bar grille**].
 - b. Air Outlet: [**Front**] [**Top**] [**Front or top**], [**quad louver**] [**punched louver**] [**extruded-aluminum bar grille**].
- 7. Horizontal, Semirecessed:
 - a. Air Inlet: [**Bottom**] [**Front**] [**Bottom or front**], [**punched louver**] [**extruded-aluminum bar grille**].
 - b. Air Outlet: [**Front**] [**Top**] [**Front or top**], [**quad louver**] [**punched louver**] [**extruded-aluminum bar grille**].
- 8. Horizontal, Fully Recessed:
 - a. Air Inlet: [**Front**] [**Duct connection**], [**punched louver**] [**extruded-aluminum bar grille**].
 - b. Air Outlet: [**Front**] [**Duct connection**], [**quad louver**] [**punched louver**] [**extruded-aluminum bar grille**].

B. Concealed Unit Heater:

- 1. Vertical: [**Upflow**] [**Downflow**].

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- a. Air Inlet: [**Open bottom**] [**Front, punched louver**] [**Front, extruded-aluminum bar grille**].
 - b. Air Outlet: [**Front**] [**Top**] [**Front or top**], [**quad louver**] [**punched louver**] [**extruded-aluminum bar grille**].
2. Horizontal: Upflow.
 - a. Air Inlet: [**Open bottom**] [**Front, punched louver**] [**Front, extruded-aluminum bar grille**].
 - b. Air Outlet: [**Front**] [**Top**] [**Front or top**], [**quad louver**] [**punched louver**] [**extruded-aluminum bar grille**].
- C. Fan:
 1. Airflow: <**Insert cfm**>.
 2. External Static Pressure: <**Insert inches wg**>.
 3. Fan Speed: <**Insert rpm**>.
 4. Motor Horsepower: <**Insert value**>.
- D. Heating Capacity:
 1. Output: <**Insert Btu/h**>.
 2. Entering-Air Temperature: <**Insert deg F**>.
 3. Air-Temperature Rise: <**Insert deg F**>.
- E. Hot-Water Heating Coil:
 1. Water Flow: <**Insert gpm**>.
 2. Water-Side Pressure Loss: <**Insert feet wg**>.
 3. Entering-Water Temperature: <**Insert deg F**>.
- F. Steam Heating Coil:
 1. Inlet Steam Pressure: <**Insert psig**>.
 2. Condensing Capacity: <**Insert lb/h**>.
- G. Electric-Resistance Heating Coil:
 1. Capacity: <**Insert kilowatts**>.
 2. Number of Steps: <**Insert number**>.
- H. Filters:
 1. Face Area: <**Insert sq. ft.**>.
 2. Thickness: [**1/2-inch**] [**1-inch**] <**Insert dimension**>.
- I. Electrical Characteristics for Single-Point Connection:
 1. Volts: <**Insert value**>.

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2. Phase: **<Insert value>**.
3. Hertz: **<Insert value>**.
4. Full-Load Amperes: **<Insert value>**.
5. Minimum Circuit Ampacity: **<Insert value>**.
6. Maximum Overcurrent Protection: **<Insert amperage>**.

2.10 DESCRIPTION – PROPELLER UNIT HEATERS:

- A. Assembly including casing, coil, fan, and motor in **[vertical]** **[and]** **[horizontal]** discharge configuration with adjustable discharge louvers.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 2021.
- D. Comply with UL 823.

2.11 PERFORMANCE REQUIREMENTS:

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- C. Seismic Performance: Propeller unit heaters shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7]** **<Insert requirement>**.
 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **[and the unit will be fully operational after the seismic event]**."

2.12 HOUSINGS:

- A. Finish: Manufacturer's **[standard]** **[custom]** baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.13 COILS:

- A. General Coil Requirements: Test and rate [**hot-water**] [**steam**] propeller unit-heater coils according to ASHRAE 33.
- B. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1-inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.
- C. Hot-Water Coil: Cupronickel tube, minimum 0.031-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1-inch and rated for a minimum working pressure of 400 psig and a maximum entering-water temperature of 450 deg F, with manual air vent. Test for leaks to 600 psig underwater.
- D. Hot-Water Coil: Red-brass tube, minimum 0.049-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1-inch and rated for a minimum working pressure of 260 psig and a maximum entering-water temperature of 390 deg F, with manual air vent. Test for leaks to 390 psig underwater.
- E. Hot-Water Coil: Steel tube, minimum 0.049-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1-inch and rated for a minimum working pressure of 400 psig and a maximum entering-water temperature of 450 deg F, with manual air vent. Test for leaks to 600 psig underwater.
- F. Hot-Water Coil: Vertical steel tube, minimum 0.065-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1-inch and rated for a minimum working pressure of 400 psig and a maximum entering-water temperature of 450 deg F, with steel headers at top and bottom. Test for leaks to 600 psig underwater.
- G. Steam Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1-inch and rated for a minimum working pressure of 75 psig.
- H. Steam Coil: Red-brass tube, minimum 0.049-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1-inch and rated for a minimum working pressure of 75 psig.
- I. Steam Coil: Vertical steel tube, minimum 0.065-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1-inch and rated for a minimum working pressure of [**100 psig**] [**200 psig**], with steel headers at top and bottom.
- J. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16-inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation.

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1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

2.14 FAN AND MOTOR:

- A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
- B. Motor: Permanently lubricated, [**explosion proof**] [**multispeed**] [**variable speed**]. Comply with requirements in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

2.15 CONTROLS:

- A. Control Devices:
 1. [**Unit**] [**Wall**]-mounted, [**variable**] fan-speed switch.
 2. [**Unit**] [**Wall**]-mounted thermostat.

2.16 CAPACITIES AND CHARACTERISTICS:

- A. Heating Capacity:
 1. Heat Output: <**Insert Btu/h**>.
 2. Length of Throw: <**Insert feet**>.
 3. Mounting Height: <**Insert feet**>.
- B. Water Coil:
 1. Entering-Water Temperature: <**Insert deg F**>.
 2. Temperature Difference: <**Insert deg F**>.
 3. Water Flow: <**Insert gpm**>.
 4. Water-Side Pressure Drop: <**Insert feet**>.
- C. Steam Coil:
 1. Inlet Pressure: <**Insert psig**>.
 2. Condensing Capacity: <**Insert lb/h**>.
- D. Electric Coil:
 1. Heating Capacity: <**Insert kilowatts**>.
 2. Number of Steps: <**Insert number**>.
- E. Supply Air:

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1. Airflow: **<Insert cfm>**.
2. Leaving-Air Temperature: **<Insert deg F>**.
3. Entering-Air Temperature: **<Insert deg F>**.

F. Fan Motor:

1. High Speed: **<Insert rpm>**.
2. Motor Size: **<Insert horsepower>**.

G. Electrical Characteristics for Single-Point Connection:

1. Volts: **<Insert value>**.
2. Phase: **<Insert value>**.
3. Hertz: **<Insert value>**.
4. Full-Load Amperes: **<Insert value>**.
5. Minimum Circuit Amperes: **<Insert value>**.
6. Maximum Overcurrent Protection: **<Insert amperage>**.

2.17 DESCRIPTION – WALL AND CEILING UNIT HEATERS:

- A. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.18 CABINET:

- A. Front Panel: [**Stamped-steel louver**] [**Extruded-aluminum bar grille**], with removable panels fastened with tamperproof fasteners.
- B. Finish: Baked enamel over baked-on primer with manufacturer's [**standard**] [**custom**] color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

2.19 COIL:

- A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-

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staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection. [**Provide integral circuit breaker for overcurrent protection.**]

2.20 FAN AND MOTOR:

- A. Fan: Aluminum propeller directly connected to motor.
- B. Motor: Permanently lubricated [, **multispeed**]. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.21 CONTROLS:

- A. Controls: Unit-mounted thermostat. [**Low-voltage relay with transformer kit.**]
- B. Electrical Connection: Factory wire motors and controls for a single field connection [**with disconnect switch**].

2.22 CAPACITIES AND CHARACTERISTICS:

- A. Airflow: <**Insert cfm**>.
- B. Fan Speed: <**Insert rpm**>.
- C. Heating Coil: <**Insert kilowatts**>.
- D. Electrical Characteristics for Single-Point Connection:
 - 1. Volts: <**Insert value**>.
 - 2. Phase: <**Insert value**>.
 - 3. Hertz: <**Insert value**>.
 - 4. Full-Load Amperes: <**Insert value**>.
 - 5. Minimum Circuit Ampacity: <**Insert value**>.
 - 6. Maximum Overcurrent Protection: <**Insert amperage**>.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and/or electrical connections to verify actual locations before unit-heater installation.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

- A. Install unit heaters to comply with NFPA 90A.
- B. Install unit heaters level and plumb.
- C. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 07 92 00 "Joint Sealants."
- D. Suspend cabinet unit heaters from structure with elastomeric hangers [**and seismic restraints**]. Vibration isolators [**and seismic restraints**] are specified in [**Section 23 05 48 "Vibration and Seismic Controls for HVAC."**] [**Section 23 05 48.13 "Vibration Controls for HVAC."**]
- E. Suspend propeller unit heaters from structure with all-thread hanger rods and [**elastomeric hangers**] [**spring hangers**] [**spring hangers with vertical-limit stop**]. Hanger rods and attachments to structure are specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in [**Section 23 05 48 "Vibration and Seismic Controls for HVAC."**] [**Section 23 05 48.13 "Vibration Controls for HVAC."**]
- F. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
- G. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- H. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
- I. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS - CABINET UNIT HEATERS:

- A. Piping installation requirements are specified in Section 23 21 13 "Hydronic Piping," Section 23 21 16 "Hydronic Piping Specialties," Section 23 22 13 "Steam and Condensate Heating Piping," and Section 23 22 16 "Steam and Condensate Heating Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

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- D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Section 23 33 00 "Air Duct Accessories."
- E. Comply with safety requirements in UL 1995.
- F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of cabinet unit heater. Hydronic specialties are specified in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 "Hydronic Piping Specialties."
- G. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of cabinet unit heater. Steam specialties are specified in Section 23 22 16 "Steam and Condensate Heating Piping Specialties."
- H. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- I. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.4 CONNECTIONS – PROPELLER UNIT HEATERS:

- A. Drawings indicate general arrangement of piping, fittings, and specialties. Piping installation requirements are specified in the following Sections:
 - 1. Section 23 21 13 "Hydronic Piping."
 - 2. Section 23 21 16 "Hydronic Piping Specialties."
 - 3. Section 23 22 13 "Steam and Condensate Heating Piping."
 - 4. Section 23 22 16 "Steam and Condensate Heating Piping Specialties."
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to propeller unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
- D. Comply with safety requirements in UL 1995.
- E. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of propeller unit heater. Hydronic specialties are specified in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 "Hydronic Piping Specialties."
- F. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of propeller unit heater. Steam specialties are specified in Section 23 22 16 "Steam and Condensate Piping Specialties."

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

- G. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- H. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL:

- A. Perform the following tests and inspections [**with the assistance of a factory-authorized service representative**]:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.6 ADJUSTING:

- A. Adjust initial temperature set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [**two**] **<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION:

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

END OF SECTION

SECTION 23 83 16

RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS:

- A. Sub-bid Requirements: As provided under Section 22 00 01 – PLUMBING SUB-BID REQUIREMENTS, and supplemental under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.
- B. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 22 00 01.

1.2 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUMMARY:

- A. Section includes radiant-heating piping, including:
 - 1. PEX pipe and fittings
 - 2. PEX-AL-PEX pipe and fittings
 - 3. Distribution manifolds
 - 4. Piping specialties
 - 5. Controls

1.4 DEFINITIONS:

- A. CWP: Cold working pressure.
- B. PEX: Crosslinked polyethylene.
- C. PEX/AL/PEX: Crosslinked polyethylene/aluminum/crosslinked polyethylene.
- D. PTFE: Polytetrafluoroethylene plastic.

1.5 ACTION SUBMITTALS:

- A. Product Data: For each type of product.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Include data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fire-performance characteristics, and water-flow and pressure-drop characteristics.
- B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.
 1. Shop Drawing Scale: [**1/4-inch = 1 foot**] <Insert scale>.

1.6 INFORMATIONAL SUBMITTALS:

- A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 1. Suspended ceiling components.
 2. Structural members to which radiant-heating piping will be attached.
 3. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. <Insert item>.
 4. Perimeter moldings.

1.7 CLOSEOUT SUBMITTALS:

- A. Operation and Maintenance Data: For radiant-heating piping valves and equipment to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS:

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Pipe Material: PEX plastic according to ASTM F876.
- C. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.
- D. Fittings: [ASTM F1807, metal insert and copper crimp rings] [ASTM F1960, cold expansion fittings and reinforcing rings].
- E. Pressure/Temperature Rating: Minimum 100 psig and 180 deg F.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.2 PEX/AL/PEX PIPE AND FITTINGS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Pipe Material: PEX plastic bonded to the inside and outside of a welded aluminum tube according to ASTM F1281.
- C. Oxygen Barrier: Limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.
- D. Fittings: ASTM F1974, metal insert fittings with split ring and compression nut (compression joint) or metal insert fittings with copper crimp rings (crimp joint).
- E. Flame-Spread and Smoke-Developed Indices: 25 and 50 or less, respectively, tested according to ASTM E84.
- F. Pressure/Temperature Rating: Minimum 100 psig and 210 deg F.

2.3 EPDM PIPE AND FITTINGS:

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Pipe Material: Crosslinked EPDM inner and outer tubes.
- C. Wall Thickness: Minimum 0.125-inch.
- D. Oxygen Barrier: Ductile aluminum foil layer applied to the inner tube to limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.
- E. Reinforcing Braid: Braided-aluminum wire between the inner and outer tube.
- F. Fittings: ASTM F1807, copper with stainless-steel crimps or clamps.
- G. Pressure/Temperature Rating: Minimum 100 psig and 210 deg F.

2.4 DISTRIBUTION MANIFOLDS:

- A. Manifold: Minimum NPS 1, [**brass**] [**copper**] [**modular plastic**] [**or**] [**stainless steel**].
- B. Main Shutoff Valves:
 - 1. Factory installed on supply and return connections.
 - 2. [**Two**] [**Three**]-piece body.
 - 3. Body: Brass or bronze.
 - 4. Ball: Chrome-plated bronze.
 - 5. Seals: PTFE.
 - 6. CWP Rating: 150 psig.
 - 7. Maximum Operating Temperature: 225 deg F.
- C. Manual Air Vents:

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Key furnished with valve, or screwdriver bit.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

D. Balancing Valves:

1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
2. Ball or Plug: Brass or stainless steel.
3. Globe Cartridge and Washer: Brass with EPDM composition washer.
4. Seat: PTFE.
5. Visual Flow Indicator: Flowmeter with visible indication in a clear plastic cap at top of valve.
6. Differential Pressure Gage Connections: Integral seals for portable meter to measure loss across calibrated orifice.
7. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
8. CWP Rating: Minimum 125 psig.
9. Maximum Operating Temperature: 250 deg F.

E. Zone Control Valves:

1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
2. Ball or Plug: Brass or stainless steel.
3. Globe Cartridge and Washer: Brass with EPDM composition washer.
4. Seat: PTFE.
5. Actuator: Replaceable electric motor.
6. CWP Rating: Minimum 125 psig.
7. Maximum Operating Temperature: 250 deg F.

F. Thermometers:

1. Mount on supply and return connections.
2. Case: Dry type, metal or plastic, [2-inch] <Insert dimension> diameter.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, connecting element and pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Black metal.
7. Window: Plastic.
8. Connector: Rigid, back type.
9. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem.
10. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

G. Mounting Brackets: Copper, or plastic- or copper-clad steel, where in contact with manifold.

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2.5 PIPING SPECIALTIES:

A. Cable Ties:

1. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
2. Minimum Width: 1/8-inch.
3. Tensile Strength: 20 lb, minimum.
4. Temperature Range: Minus 40 to plus 185 deg F.

B. Floor Mounting Staples:

1. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
2. Minimum Thickness: 3/32-inch.
3. Width: Minimum, wider than tubing.

C. Floor Mounting Clamps:

1. Two bolts, steel, with corrosion-resistant coating and smooth finish without sharp edges.
2. Minimum Thickness: 3/32-inch.
3. Width: Minimum, wider than tubing.

D. Floor Mounting Tracks:

1. Aluminum or plastic channel track with smooth finish and no sharp edges.
2. Minimum Thickness: 1/16-inch.
3. Slot Width: Snap fit to hold tubing.
4. Slot Spacing: [2-inch] [3-inch] <Insert dimension> intervals.

E. Channeled Subfloor:

1. Plywood, APA-rated subfloor panel, composed of premium, tongue-and-groove, seven-layer, Douglas fir structural subfloor panels.
2. Particleboard manufactured to comply with Federal Housing Authority standards of less than 0.3-ppm formaldehyde.
3. Clad panel with minimum 0.025-inch-thick aluminum recessed in the grooves sized to maintain contact with radiant piping.

F. Modular Interlocking Blocks:

1. Polypropylene snap-together blocks with grooves to support piping.
2. Galvanized sheet metal or aluminum emission plates.
3. Natural mineralboard cover panel.

G. Heat-Emission Plates:

1. Formed aluminum suitable for radiant-heating piping.
2. Minimum Thickness: 1/16-inch.
3. Slot Width: Snap fit to maintain pressure fit on tubing.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2.6 CONTROLS:

- A. Temperature-control devices and sequence of operations are specified in Section 23 09 23 "Direct Digital Control (DDC) System for HVAC" and Section 23 09 93.11 "Sequence of Operations for HVAC DDC."
- B. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- C. Wall-Mounted Thermostat:
 - 1. Minimum temperature range from [**50 to 90 deg F**] **<Insert temperature range>**.
 - 2. Manually operated with on-off switch.
 - 3. Day and night setback and clock program with minimum four periods per day.
 - 4. Operate pumps or open zone control valves if room temperature falls below the thermostat setting, and stop pumps or close zone control valves when room temperature rises above the thermostat setting.
- D. Heated-Panel Thermostat:
 - 1. Remote bulb unit with adjustable temperature range from [**50 to 90 deg F**] **<Insert temperature range>**.
 - 2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump or zone control valve.
 - 3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant-panel temperature.
 - 4. Stop pump or close zone control valves if heated-panel thermostat setting is exceeded.
 - 5. Corrosion-resistant, waterproof control enclosure.
- E. Heated-Panel Thermostat with Outdoor Temperature Reset:
 - 1. Remote bulb unit with adjustable temperature range from [**50 to 90 deg F**] **<Insert temperature range>**.
 - 2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump or zone control valve.
 - 3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant-panel and outdoor-air temperature.
 - 4. Operate zone control valves to reset supply-water temperature inversely with outdoor-air temperature as follows:
 - a. Low outdoor-air temperature, [**0 deg F**] **<Insert temperature>** with high supply-water temperature [**110 deg F**] **<Insert temperature>**.
 - b. High outdoor-air temperature, [**60 deg F**] **<Insert temperature>** with low supply-water temperature [**70 deg F**] **<Insert temperature>**.
 - 5. Corrosion-resistant, waterproof control enclosure.
- F. Precipitation and Temperature Sensor:
 - 1. [**Microprocessor-based**] [**Automatic**] control with manual on, automatic, and standby/reset switch.

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2. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to operate pump and zone control valves as follows:
 - a. Temperature Span: [34 to 44 deg F] <Insert temperature range>.
 - b. Adjustable Delay Off Span: [30 to 90] <Insert numbers> minutes.
 - c. Start Pump or Open Zone Control Valves: Following [two] <Insert number>-minute delay if ambient temperature is below set point and precipitation is detected.
 - d. Stop Pump or Close Zone Control Valves: On detection of a dry surface plus time delay.
3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
4. Minimum 30-A contactor to start pump and open valves.
5. Precipitation sensor shall be mounted in pavement.
6. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control-system workstation.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine surfaces and substrates to receive radiant-heating piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 1. Ensure that surfaces and pipes in contact with radiant-heating piping are free of burrs and sharp protrusions.
 2. Ensure that surfaces and substrates are level and plumb.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS:

- A. Install the following types of radiant-heating piping for the applications described:
 1. Piping in Exterior Pavement: [EPDM] [PEX] [PEX/AL/PEX].
 2. Piping in Interior Reinforced-Concrete Floors: [EPDM] [PEX] [PEX/AL/PEX].
 3. Piping in Level Fill Concrete Floors (Not Reinforced): [EPDM] [PEX] [PEX/AL/PEX].
 4. Piping in Ceilings: [EPDM] [PEX] [PEX/AL/PEX].
 5. Piping in Subfloors: [EPDM] [PEX] [PEX/AL/PEX].
 6. Piping below Wood Floors: [EPDM] [PEX] [PEX/AL/PEX].

3.3 INSTALLATION:

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings or coordination drawings.

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- B. Install radiant-heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.
- C. Connect radiant piping to manifold in a reverse-return arrangement.
- D. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.
- E. Install manifolds in accessible locations, or install access panels to provide maintenance access as required in Section 08 31 13 "Access Doors and Frames."
- F. Comply with requirements in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 "Hydronic Piping Specialties" for pipes and connections to hydronic systems and for glycol-solution fill requirements.
- G. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Section 07 84 13 "Penetration Firestopping."
- H. Piping in Exterior Pavement:
 - 1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 - 2. Space cable ties a maximum of [18-inches] <Insert dimension> o.c. and at center of turns or bends.
 - 3. Maintain [3-inch] <Insert dimension> minimum cover.
 - 4. Install a sleeve of 3/8-inch-thick, foam-type insulation or PE pipe around tubing and extending for a minimum of [10-inches] <Insert dimension> on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - 5. Maintain minimum 40-psig pressure in piping during concrete placement and continue for 24 hours after placement.
- I. Piping in Interior Reinforced-Concrete Floors:
 - 1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 - 2. Space cable ties a maximum of [18-inches] <Insert dimension> o.c. and at center of turns or bends.
 - 3. Maintain [2-inch] <Insert dimension> minimum cover.
 - 4. Install a sleeve of 3/8-inch-thick, foam-type insulation or PE pipe around tubing and extending for a minimum of [10-inches] <Insert dimension> on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - 5. Maintain minimum 40-psig pressure in piping during concrete placement and continue for 24 hours after placement.
- J. Piping in Level Fill Concrete Floors (Not Reinforced):
 - 1. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
 - 2. Space tracks, clamps, or staples a maximum of [18-inches] <Insert dimension> o.c. and at center of turns or bends.
 - 3. Maintain [3/4-inch] <Insert dimension> minimum cover.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

4. Install a sleeve of 3/8-inch-thick, foam-type insulation or PE pipe around tubing and extending for a minimum of [**10-inches**] <Insert dimension> on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig pressure in piping during the concrete pour and continue for 24 hours during curing.

K. Piping in Ceiling:

1. Secure piping by attaching pipes to ceiling substrate using clamps or staples.
2. Space clamps or staples a maximum of [**18-inches**] <Insert dimension> o.c. and at center of turns or bends.
3. Maintain [**1-1/2-inch**] <Insert dimension> minimum plaster cover.
4. Maintain minimum 40-psig pressure in piping during the plaster application and continue for 24 hours during curing.

L. Piping in Subfloor:

1. Secure piping by laying in subfloor channels or modular interlocking blocks.
2. Use straight channel panels or blocks in the center and curved channel panels or blocks at the ends.
3. Finish floor with mineralboard panel cover or finished floor surface.

M. Piping below Wood Floor:

1. Secure piping by attaching pipes to subfloor using heat-emission plates, clamps, or staples.
2. Space heat-emission plates, clamps, or staples a maximum of [**4-inches**] <Insert dimension> o.c. and at center of turns or bends.
3. Install heat-emission plates on underside of wood subfloor with maximum space between plates, as noted above, to maintain pipe contact with floor.

N. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

O. After system balancing has been completed, mark balancing valves to permanently indicate final position.

P. Perform the following adjustments before operating the system:

1. Open valves to fully open position.
2. Check operation of automatic valves.
3. Set temperature controls so all zones call for full flow.
4. Purge air from piping.

Q. After concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant-heating system as follows:

1. Start system heating at a maximum of 10 deg F above the ambient radiant-panel temperature and increase 10 deg F each following day until design temperature is achieved.

Preparer should not complete or utilize this section without review and approval of a MEP engineer.

2. For freeze protection, operate at a minimum of 60 deg F supply-water temperature.

3.4 FIELD QUALITY CONTROL:

- A. Prepare radiant-heating piping for testing as follows:
 1. Open all isolation valves and close bypass valves.
 2. Open and verify operation of zone control valves.
 3. Flush with clean water and clean strainers.
- B. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 1. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than **[100 psig]** <Insert value>. Repair leaks and retest until no leaks exist.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Radiant-heating piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Protect hydronic piping system from damage during construction.

END OF SECTION

SECTION 26 00 00
ELECTRICAL
(Filed Sub-Bid Required)

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END OF INDEX

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PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary."
- B. Time, Manner and Requirements for Submitting Sub-Bids:
1. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the Awarding Authority at a time and place as stipulated in the "NOTICE TO CONTRACTORS".

The following should appear on the upper left hand corner of the envelope:

NAME OF SUB-BIDDER: (Insert name of sub-bidder)

MASS. STATE PROJECT: ((Insert project number from top of page))

SUB-BID FOR SECTION: 260000 – ELECTRICAL

2. Each sub-bid submitted for work under this Section shall be on forms furnished by the Awarding Authority as required by Section 44F of Chapter 149 of the General Laws, as amended. Sub-bid forms may be obtained at the office of the Awarding Authority or may be obtained by written or telephone request.
 3. Sub-bids filed with the Awarding Authority shall be accompanied by BID BOND or CASH or CERTIFIED CHECK or TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company payable to the Awarding Authority in the amount of five percent of the sub-bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.
- C. Trade-Sub Bid Requirements:

Class of Work	Section Number
Communications	27 00 00

Emergency Responder Radio Signal Amplification system (BDA System)	275319

Electronic Safety And Security	28 00 00

If Sub-Bidder intends to perform with persons of his own staff the classes of work listed above, he must nevertheless list his own name therefore, under Paragraph E, of the FORM FOR SUB-BID.

- D. Reference Drawings: The Work of this Filed Sub-Bid is shown on the following Contract Drawings:
- E. The Trade Contractor shall also examine all other Drawings and all other Sections of the Specifications for requirements therein affecting the Work of this Section, not just those pertaining to this Sub-trade. Where The drawings for this trade contractors work reference another trades drawing for information, that referenced scope shall be provided in this trades bid.

1.02 GENERAL REQUIREMENTS

- A. The Conditions of the Contract and General Requirements of the Project Manual apply to this Subcontractor, material suppliers, and all other persons furnishing labor and materials under this Section. The General Conditions, and applicable parts of Division 01 are included as part of this Section.
- B. Examine all Project Specifications and Drawings for requirements which affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.
- D. The following definitions apply to the Drawings and Specifications:
 - 1. Furnish: The term "furnish" is used to mean "supply and deliver to the Project Site, ready for unloading, unpacking, assembly, installation, and similar operations".
 - 2. Install: The term "install" is used to describe operations at the Project Site including actual "unloading, unpacking, assembly, erection, piecing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations".
 - 3. Provide: The term "provide" is used to mean "furnish and install, complete and ready for the intended use".
 - 4. Installer: An "installer" is the Contractor or an entity engaged by the Contractor, either as an employee, Subcontractor, or Sub-Subcontractor for performance of a particular construction activity, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.
- E. When open-flame or spark producing tools such as blow torches, welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four (24) hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant non-working fire watch where work is being performed until it is completed.
- F. E.C. shall Keep fully informed as to the shape, size and position of all openings required for all apparatus and give information in advance to build openings into the work.
- G. All distribution systems which require pitch or slope such as plumbing drains, steam and condensate piping shall have the right of way over those which do not. Confer with other trades as to the location of pipes, ducts, lights and apparatus and install work to avoid interferences.

- H. Coordinate exact locations and roughing in dimensions of all work before installation and make all final connections as required. Any changes required to avoid interference or to provide adequate clearances for Code and maintenance requirements shall be made at no additional costs.
- I. Structural elements of the project shall not be relocated, altered or changed to accommodate the work without written authorization from the Architect.
- J. Work that is installed before coordination with other trades, or that causes interference with the work of other trades shall be changed to correct condition.
- K. Obtain a complete set of Project Drawings and Specifications for coordination and to determine the full scope of work.
- L. Attend project coordination meetings to coordinate work of this Section, work of other trades and project and phasing retain a complete set of Project Drawings and Specifications for coordination and to determine the full scope of work.

1.03 DESCRIPTION OF WORK

- A. Work described herein shall be interpreted as work to be done by the Electrical Sub-Contractor. Work to be performed by other trades will be referenced to a particular contractor.
- B. Provide all labor, materials, tools, and equipment, including scaffolding, to complete the installation of the electrical system. Install, equip, adjust, and put into operation the respective portions of the installation specified, and so interconnect various items or sections of work in order to form a complete and operating whole. Systems may be referenced in singular or plural terms, also refer to drawings to confirm quantities.
- C. Where the Contract drawings conflict with themselves or the specifications. The contractor shall carry the higher quantity or quality.
- D. The work shall consist of, but shall not necessarily be limited to the following:
 - 1. Primary, secondary and low tension duct banks, manholes, and handholes.
 - 2. Secondary distribution equipment, including distribution panels, metering, motor controls, variable frequency drives, panelboards, including feeders and sub-feeders.
 - 3. Fire alarm system, addressable type
 - 4. Emergency power system, including diesel fueled emergency generators, transfer switches, manual transfer switches and emergency lighting and exit signs.
 - 5. Lighting systems exterior and interior fixtures, and a complete automated addressable lighting control system with all sensors occupancy, daylight, photosensors, switches and Bacnet BMS integration.
 - 6. Multiple Check Metering System in compliance with ASHRAE 90.1, 8.4.3
 - 7. Power wiring water sub-meters.
 - 8. Photovoltaic provisions.
 - 9. EV Charging Stations
 - 10. Automated Lighting Control System, including start-up, programming, and coordination with Owner for the schedules and scene programs.
 - 11. All raceway systems, including boxes, couplings, and fittings.
 - 12. All branch circuit wiring systems, including wiring devices and plates.

13. Excavation and backfill within building foundation walls for any underground raceways including those not specifically shown on the drawings.
14. Connections for all building equipment, including mechanical, plumbing, and fire protection, Elevator, Owner's equipment and the like.
15. Power for Fuel Island Fire Suppression System, refer to Section 21 24 00 Fuel Island Fire Suppression System for requirements.
16. All testing of equipment installed.
17. Drilling, coring, and cutting of holes for electrical conduit systems, and equipment. Where the electrical contractor requires the G.C. to provide cutting and patching the E.C. shall reimburse the G.C. for the work done. Any cutting caused by the E.C. that causes delay due to poor coordination of the sequencing of work shall be reimbursed by the contractor performing the work. Drilling, coring, and cutting of holes (where the largest dimension thereof does not exceed 12 inches) for electrical conduit systems, and equipment.
18. Systems Identification.
19. Hoisting Equipment and Machinery: Unless otherwise specified, all hoisting equipment and machinery required for the proper and expeditious prosecution and progress of the work shall be furnished, installed, operated and maintained in safe condition by the individual Non Trade and Trade Contractors and is so stated in each appropriately related Section of the Specifications. All costs for hoisting operating services shall be borne by the Non Trade and Trade Contractors unless specifically excepted in the Contract Documents.
 - a. A licensed equipment manufacturer's representative shall be present at all times, to witness the erection and dismantling of all hoisting equipment and machinery, whenever such equipment is being erected or dismantled. No such work will be performed without the presence of such representative.
 - b. Hoisting equipment and machinery erection and dismantling shall be performed only by trained, certified, and experienced riggers qualified to perform such work.
20. Scaffolding, Rigging, and Staging required for all Electrical Work. Refer to section 01 50 00 – Temporary Facilities.
21. Temporary Light and Power, refer to Section 01 50 00 –TEMPORARY FACILITIES AND CONTROLS.
22. Coordination of Firestopping for all Electrical Systems. Refer to Section 07 84 13 for further definition.
23. Provide Seismic Restraints for all Electrical Systems conforming to the requirements of Section 23 05 48 which Section is herein incorporated by reference.
24. Coordination Drawings.
25. Lightning Protection System.
26. Uninterruptible Power Supply, UPS System.
27. Communications system provisions including 120 volt power sources, cable tray, j-hooks, raceways and backboxes for Communications Systems as shown on drawings and specified in Section 27 00 00, Communications.
28. Integrated Electronic Security System provisions, IESS including 120 volt power sources, cable tray, j-hooks, raceways, and backboxes for security systems as shown on drawings and specified in Div. 28 Electronic Safety and Security
29. Sealing of all penetrations through walls, slabs, partitions, that are not fire rated.
30. Detention Area cell door remote electronic release control panel and associated power supplies and wiring.
31. Two-way Communications assistance call boxes system.
32. BIM Coordination
33. BDA System – Refer to section 27 53 19

34. Access doors and frames, Refer to Section 08 31 13.
35. Testing of all equipment installed by this contractor.
36. Commissioning - 01 81 00
37. Provide all requirements for Electrical Distribution Systems that either directly serve or a percentage thereof that support the Geothermal Energy Project in accordance with Section 007343.01-1 Wate Rate Schedules & Training.
 - a. The Geothermal Energy Project consists of the following HVAC equipment and systems: Geothermal groundwater source water to water heat recovery heat pump chillers, connected ground source condenser water piping, chilled water, hot water piping, piping and equipment insulation, pumps, valves, air separators, expansion tanks, buffer tanks, accessories, rooftop and indoor air handling units, ductwork, ductwork accessories, ductwork insulation, dampers, air distribution devices, and controls.
 - b. HVAC Systems that are not included in the Geothermal Energy Project Scope include the following HVAC equipment sand systems that are not connected to the Geothermal system as defined above: Exhaust air fans (including General Exhaust, Dust collector, Kitchen exhaust, system, other Specialty Exhaust) systems and associated exhaust ductwork and controls, electric resistance heating equipment, Air source or air cooled split system AC or heat pump units and related refrigerant, condensate piping, accessories and controls, miscellaneous ATC control points.
38. Any other item of work herein specified or indicated on electrical drawings.

1.04 DEFINITIONS

- A. Most terms used within the documents are industry standard. Certain words or phrases shall be understood to have specific meanings as follows:
 1. Reviewed: When used to convey Designer's action on General Contractor's submittals, applications and requests, "reviewed" is limited to Designer's duties and responsibilities as stated in the Conditions of the Contract.
 2. Directed: A command or instruction by Designer. Other Terms including "requested", "authorized", "selected", "approved", "required" and "permitted" have the same meaning as "directed".
 3. Indicated: Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including "shown", "noted", "scheduled" and "specified" have the same meaning as "indicated".
 4. Regulations: Laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, and rules, conventions and agreements within the construction industry that control performance of the Work.
 5. Furnish: Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation and similar operations.
 6. Install: Operations at Project site including unloading, temporarily storing, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning and similar operations.
 7. Conduit: Raceways of the metallic type which are not flexible. Specific types as specified.
 8. Connect: To wire up, including all branch circuitry, control and disconnection devices so item is complete and ready for operation.

9. Subject to Mechanical Damage: Equipment and raceways installed exposed and less than eight feet above finished floor in mechanical rooms or other areas where heavy equipment may be in use or moved.
 10. Provide: Furnish and install completely connected up and in operable condition.
- B. General: Basic Contract definitions are included in the Conditions of the Contract including, but not limited to, the following:
1. The Designer (the Architect-of-Record or Engineer-of-Record as applicable.)
 2. The Owner's Project Manager.
 3. The General Contractor.

1.05 ITEMS TO BE FURNISHED ONLY

- A. Furnish the following items for installation under designated sections.
1. Duct smoke detectors with sampling tube, Section 23 00 00 – HVAC.
 2. Pre-cast pole bases to be installed by Site contractor.
 3. Manholes and handholes – Site Contractor
 4. Access Doors and Panels - Section 08 31 13.

1.06 ITEMS TO BE WIRED ONLY

- A. Install the following items furnished under designated sections.
1. Electronic faucet control transformers, Section 22 00 00 – Plumbing.
 2. Appliances and Equipment, Division 11 – Equipment
 3. Motorized Roller Window Shades, SECTION 12 24 00.
 4. Overhead Coiling Doors 08 33 23

1.07 RELATED WORK

- A. The following related work is to be performed under designated sections.
1. Temp. Controls – SECTION 01 50 00 - TEMPORARY FACILITIES AND CONDROLS.
 2. Excavation and Backfill: DIVISION 31 – EARTHWORK (except within building foundation).
 3. Poured in place Pads and Duct bank Envelopes: DIVISION 03 - CONCRETE.
 4. Insulation - SECTION 07 21 00 – THERMAL INSULATION.
 5. Finish Painting: SECTION 09 90 00 – PAINTING AND COATING.
 6. Payment for energy for temporary light and power shall be made by General Contractor. Refer to SECTION 01 50 00, TEMPORARY FACILITIES AND CONTROLS.
 7. Automatic Temperature Control: SECTION 23 00 00 - HEATING, VENTILATING & AIR CONDITIONING.
 8. Hardware: SECTION 08 71 00 – DOOR HARDWARE
 9. Hardware: SECTION 08 71 13 – AUTOMATIC DOOR OPERATORS
 10. Hardware: SECTION 08 71 63 – DETENTION DOOR HARDWARE

11. Communications System Equipment and Wiring: SECTION 27 00 00 –COMMUNICATIONS.
12. Emergency Responder Radio Signal Amplification System (BDA System): SECTION 27 53 19 – EMERGENCY RESPONDER RADIO SIGNAL AMPLIFICATION SYSTEM (BDA SYSTEM)
13. Electronic safety and security - Division 28
14. Temporary Light and Power – Section 01 51 00 - TEMPORARY FACILITIES AND CONTROLS.
15. Fire stopping: Division 07 84 13 – PENETRATION FIRESTOPPING.
16. Scaffolding, Rigging, and Staging required for all Electrical Work over (8) Eight ft. in height. Refer to section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS.
17. Power requirements for Vehicle Exhaust Capture system – 230000 – HVAC
18. Shades, SECTION 12 24 00.
19. Equipment, Division 11
20. Overhead coiling Doors - 08 33 23

1.08 ENVIRONMENTAL REQUIREMENTS

- A. The work of this section shall comply with requirements of the following:
 1. SECTION 01 31 00 – PROJECT MANAGEMENT AND COORDINATION
 2. SECTION 01 40 00 – QUALITY REQUIREMENTS
 3. SECTION 01 81 19 – INDOOR AIR QUALITY REQUIREMENTS
 4. SECTION 01 81 00 - COMMISSIONING

1.09 CONTRACT COST BREAKDOWN

- A. Submit a breakdown of contract price to aid Architect in determining value of work installed as job progresses. The submission shall be broken out by Sitework, and Building Work. Each should then be further broken out by materials, rough-in and finish work.

1.10 INSPECTION OF SITE

- A. Electrical bidders will be permitted to inspect site. Failure to inspect existing conditions or to fully understand work which is required shall not excuse Electrical Subcontractor from his obligations to supply and install work in accordance with specifications and the drawings and under all site conditions as they exist.

1.11 CONTRACTOR'S REPRESENTATIVE

- A. Retain a competent representative on the project. It is prohibited to substitute the representative prior to approval from the Owner.

1.12 COOPERATION

- A. Work shall be carried on under usual construction conditions, in conjunction with other contractors work. Cooperate with other contractors, coordinate work and proceed in a manner as not to delay progress.

- B. Before proceeding, examine all construction drawings and consult other contractors to coordinate installation and avoid interference.
- C. In case of dispute, the Architect will render a decision in accordance with General and Supplementary General Conditions.

1.13 CODES, ORDINANCES, AND PERMITS

- A. Codes and Ordinances:
 - 1. All material and work provided shall be in accordance with all applicable codes including the following codes and standards as most recently amended.
 - State Building Code
 - Massachusetts Electric Code, 2023 Edition
 - State Department of Public Safety
 - NFPA 101 Life Safety Code
 - NFPA Standards
 - NEMA TCB2-2017
 - Standards of the Underwriters Laboratories (UL)
 - Occupational Safety and Health Act (OSHA)
 - Americans with Disabilities Act (ADA)
 - Energy Conservation Code
 - Town of Truro
- B. Where contract documents indicate more stringent requirements than codes, the contract documents shall take precedence.
- C. Permits: Be responsible for filing documents, and securing of inspection and approvals. Pay all permit fees.
- D. Refer to Division 01. Utility company backcharges related to permanent service will be paid by Owner.

1.14 COMMISSIONING REQUIREMENTS

- A. An independent Commissioning Agent (CxA) will be retained for this project. The commissioning process will be implemented in accordance with industry standard commissioning protocols and procedures.
- B. Complete installation and startup checks and functional tests according to Commissioning specifications.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start-up procedure.
- D. Verify that equipment is installed and commissioned as per requirements of commissioning specifications manufacturers written instructions/requirements.

- E. Inform Commissioning Agent at least one week prior to startup and/or programming of lighting control system.
- F. Refer to SECTION 01 81 00 –COMMISSIONING

1.15 ELECTRICAL ROOMS OR SPACES

- A. Be responsible for ensuring that the dedicated space and clearances required in the NEC, Sections 110-26 are maintained for all electrical equipment.
- B. Call other contractors' attention to the requirements contained in the above mentioned code sections, prior to the installation of equipment by other contractors, in order to ensure no violations.

1.16 SUBMITTALS

- A. Refer to Supplementary General Conditions for information relative to submission of shop drawings. Submittals shall be electronic in PDF format. No equipment shall be installed prior to approval.
- B. Notwithstanding any restrictions upon contractor proposed substitutions, should apparatus or materials be permitted by Architect to be substituted for those specified for good cause, and such substitution necessitates changes in or additional connections, piping, supports, or construction, same shall be provided. Assume cost and entire responsibility thereof.
- C. Submit the following samples:
 - 1. Lighting fixtures as may be requested.
 - 2. Other items as may be requested.
- D. Refer to Section 01 33 00 – SUBMITTAL REQUIREMENTS

1.17 GUARANTEE

- A. All parts of the work shall be guaranteed for a period of one (1) year from the date of acceptance of the job by Owner. If during that period of general guaranty, any part of the work fails, becomes unsatisfactory, or does not function properly due to any fault in material or workmanship whether or not manufactured or job built, the Owner shall upon notice from owner promptly proceed to repair or replace such faulty material or workmanship without expense to owner, including cutting, patching, and painting, or other work involved, and including repair or restoration of any damaged sections of the premises resulting from such faults.
- B. In the event that a repetition of any one defect occurs indicating the probability of further failure and which can be traced to faulty design, material, or workmanship, then repair or replacement shall not continue to be made but the fault shall be remedied by a complete replacement of the entire defective unit.

- C. In addition to the general guaranty, obtain and transmit to owner any guaranties or warranties from manufacturers of specialties, but only as supplementary to the general guaranty which will not be invalidated by same.

1.18 ELECTRICAL CHARACTERISTICS

- A. In general, and unless specifically indicated otherwise, all building service, heating, ventilating, air conditioning, and plumbing equipment shall be of the following characteristics:
 - 1. Motors up to and including 1/3 HP shall be suitable for 120 volts, one phase operation.
 - 2. Motors larger than 1/3 HP shall be suitable for 480 volts, three-phase operation.
 - 3. Electric heating equipment 4.0 KW and less shall be suitable for 277 volt single-phase operation. Over 4.0 KW shall be 480 volt, three phase.
- B. Power Factor: All equipment provided rated greater than 1,000 watts and lighting equipment greater than 15 watts with an inductive reactance load component shall have a power factor of not less than 90 percent under rated load conditions.

1.19 TEMPORARY ELECTRICAL SUPPORT FACILITIES

- A. Refer to Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS.
- B. Provide own field office and/or storage facilities which shall be located as directed by the Architect. Provide all tools, equipment, ladders, and temporary construction required for execution of the work.
- C. All scaffolding, ladders, and other temporary construction shall be rigidly built in accordance with all local and state requirements, and shall be removed upon completion.

1.20 INSPECTIONS AND TESTS

- A. Inspection: If inspection of materials installed shows defects, such defective work, materials, and/or equipment shall be replaced and inspection and tests repeated.
- B. Tests: Make reasonable tests and prove integrity of work and leave electrical installation in correct adjustment and ready to operate. All panels shall have phases balanced as near as practical. A consistent phase orientation shall be adhered to at all terminations.

1.21 ENERGY REBATE PROGRAM

- A. This project has been designed to incorporate equipment approved for energy rebate such as fixtures, performance lighting, building lighting controls, and VFDs. Meet with Utility Company prior to lighting shop drawing submittal to ascertain that submittal meets program guidelines. Fixtures shall be DLC listed or equivalent. Assist Owner and Engineer in effort to obtain utility rebates the Owner is eligible for. Equivalent lighting fixtures which meet DLC shall require lighting vendor to submit shop drawings to utility company for approval. It is the intent of this project to Qualify for incentives which requires an additional 30 days of reported kWh saved and six months of lighting energy use data as reported by the system post-installation.

1.22 RECORD DRAWINGS

- A. Refer to Section 01 77 00 Closeout Procedures and 01 78 39 Project Record Documents for additional requirements. Provide two sets of black or blue line on white drawings to maintain and submit record drawings, one set shall be maintained at site and which shall be accurate, clear, and complete showing actual location of all equipment as installed. Record drawings shall be updated at least monthly. Record drawings shall show outlet from which homeruns are taken, and location of all junction boxes and access panels. These drawings shall be available to Architect/Engineer field representative.
- B. Any addenda sketches and supplementary drawings issued during course of construction shall be incorporated in drawings.
- C. At completion, submit an accurate checked set of drawings.
- D. After approval of these drawings, photo reproductions of original tracings shall be revised to incorporate changes, including addenda sketches and supplementary drawings. Fitup drawings for tenant areas shall also be revised in the same manner. These "as-built" photo reproductions shall be certified as correct and delivered to the Architect along with two (2) sets of black line prints and Auto CAD files on thumb drive of all changes.

1.23 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Operating Instructions: Refer to Section 01 77 00 – Closeout Procedures and 01 78 23 Operations and Maintenance Data. Furnish operating instructions to Owner's designated representative with respect to operations, functions and maintenance procedures for equipment and systems installed. Cost of such instruction up to a full three (3) days of Electrical Subcontractor's time shall be included in contract. Cost of providing a manufacturer's representative at site for instructional purposes shall also be included.
- B. Maintenance Manuals:
 - 1. At completion of the project, provide four copies of complete manuals containing the following:
 - a. Complete shop drawings of equipment.
 - b. Operation description of systems.
 - c. Names, addresses, and telephone numbers of suppliers of systems.
 - d. Vendors' P.O. numbers for equipment installed.
 - e. Preventive maintenance instructions for systems.
 - f. Spare parts list of system components.
 - 2. All information shall be in one binder.

1.24 COORDINATION DRAWINGS

- A. Refer to Section 01 31 00 – Project Management and Coordination, before materials are purchased or work is begun, prepare and submit to the Architect, Coordination Drawings showing the size and location of all equipment and piping lines relevant to the complete system. Ensure that these Drawings are compatible and correctly annotated and cross-referenced at their interfaces.

- B. The General Trades Contractor shall be responsible for the coordination of all mechanical and electrical work. Before materials are fabricated or work begun, he shall submit to the Architect complete Coordination Drawings in the form of reproducible transparencies at not less than 1/4 inch scale. Congested areas and sections through shafts shall be prepared at not less than 3/8 inch scale, such areas being as determined by the Architect. The General Trades Contractor may request electronic files, from the Architect, to generate the indication of the building shell background for the Coordination Drawings.
 - C. Coordination Drawings shall indicate the necessary offsets for all ductwork, piping, conduit, and other items to clear the work of all other trades and to maintain the required ceiling height and partition layout. Each subcontractor shall indicate both top and bottom elevations of their equipment taking into account hangers, flanges, and other accessories.
 - D. Prepare Coordination Drawings as follows:
 - 1. The General Trades Contractor shall require the HVAC Subcontractor to prepare original Drawings showing all his/her equipment, ducts, and piping on these transparencies.
 - 2. The General Trades Contractor shall have vellum transparencies made therefrom.
 - 3. The General Trades Contractor shall then require the PLUMBING Subcontractor to indicate all Plumbing piping and heating lines.
 - 4. The General Trades Contractor shall then require the FIRE PROTECTION Subcontractor to indicate all his/her equipment and piping on these transparencies.
 - 5. The General Trades Contractor shall then require the ELECTRICAL Subcontractor to indicate all his/her equipment and conduit lines on these transparencies.
 - 6. The General Trades Contractor shall resolve conflicts and then submit these transparencies to the Architect for review.
 - E. Coordination Drawings shall bear the signature of all Subcontractors involved indicating that all space conditions have been satisfactorily resolved. In addition, the Drawings shall bear the Contractor's stamp bearing the notation "Drawings Have Been Checked and Coordinated With All Trades". Drawings without these notations will not be accepted by the Architect.
 - F. If any space conflicts cannot be resolved by the Contractor, he shall immediately notify the Architect and request disposition of the conflict.
 - G. Coordination Drawings are for the Contractor's and Architect's use during construction and shall not be construed as replacing any Shop, "As-Built", or Record Drawings required elsewhere in these Contract Documents.
 - H. Architect's review of Coordination Drawings shall not relieve the Contractor from his overall responsibility for coordination of all work performed pursuant to the Contract or from any other requirement of the Contract.
 - I. Refer to Section 01 77 00 – CLOSEOUT PROCEDURES for further requirements and procedures.
- 1.25 RETURN AIR PLENUM
- A. All wiring above suspended ceilings shall be "UL Listed" plenum rated cable or wiring shall be installed in conduit.

1.26 TECHNOLOGY AND IESS SYSTEM PROVISIONS

- A. The work shall be so performed so that the progress of the entire building construction, including all other trades, shall not be delayed and not interfered with. Materials and apparatus shall be installed as fast as conditions of the building will permit and must be installed promptly when and as directed.
- B. The Electrical Contractor shall be responsible for furnishing and installing: conduits from each door strike, latch, mag lock, door contact, electric closures, card reader, etc. to an accessible ceiling space. Provide power and fire alarm interface at each power supply, door controller requiring same.
- C. The Electrical Contractor shall be responsible for coordinating with the Owners security vendor for locations, heights, etc. of provisions.
- D. Responsibilities of the Electrical Contractor: The Electrical Contractor shall be responsible for furnishing and installing all related building preparation including, but not limited to: outlet boxes with plaster rings, 120 volt, power, surface raceways, conduits with bushings, conduit stubs with bushings, sleeves with bushings (all conduits, stubs, sleeves, etc. shall be brought to an accessible ceiling of the same floor), backboxes, plaster rings, pull strings, j-hooks (every 5 feet along main paths to communications closets), bonding, grounding, core drilling, cutting, environmental seals, seismic supports, etc., for a completely operational system, as specified. Special backboxes furnished by Owners security vendor and Communications System Contractors, shall be installed by Electrical Contractor.
- E. Responsibilities of the Communications System Contractors: The Communications System Contractor will be responsible for furnishing, installing, wiring, programming, troubleshooting, training and warranty service of all cabling, terminal equipment, headend equipment, as specified in Section 27 00 00 for a completely operational system.
- F. Responsibilities of the Integrated Electronic Security Systems Division 28 (IESS) Contractor will be responsible for furnishing, installing, wiring, programming, trouble shooting, training, and warranty service of all cabling, terminal equipment, and head-end equipment for a completely operational system.
- G. Electrical Contractor shall work closely with the Technology and Security System Contractors to assure a first class installation. Coordinate all back boxes and conduits required prior to installations. In general, the electrical contractor shall provide conduits from outlets to accessible ceiling spaces.
- H. Responsibilities of the Electrical Contractor: The Electrical Contractor shall be responsible for furnishing and installing all related system provisions including, but not limited to: power, cable trays, conduits with bushings, conduit stubs with bushings, sleeves with bushings, backboxes, plaster rings, pull strings, bonding, grounding, for a completely operational system. Specialty backboxes will be furnished by Technology and installed under Section 260000.

1.27 TEMPORARY LIGHT & POWER

- A. Refer to Section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS.

1.28 STAGING AND SCAFFOLDING

- A. Unless otherwise specified, each sub-contractor shall provide all lifts and man-lifts, and furnish, erect and maintain in safe condition, all staging and scaffolding as specified under Section 015000 Temporary Facilities, as needed for proper execution of the work of this Section. Staging and scaffolding shall be of adequate design, erected and removed by experienced stage builders having all accident prevention devices required by Federal, state and local laws.

1.29 HOISTING EQUIPMENT AND MACHINERY

- A. Unless otherwise specified, all hoisting and rigging equipment and machinery required for the proper and expeditious prosecution and progress of the Work of this Section shall be furnished, installed, operated and maintained in safe condition by this sub-contractor, as specified under Section 01 50 00, TEMPORARY FACILITIES AND CONTROLS.

1.30 ALTERNATES

- A. Refer to Section 01 23 00 for Alternates affecting this section.

1. TBD

- B. Include in your bid a separate price for amounts to be added or deducted from base bid amount for the following areas of Electrical work:

1. NONE

1.31 TRADE RESPONSIBILITY COORDINATION MATRIX

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Smoke Detectors (Area type)	26 00 00	26 00 00	26 00 00	23 00 00 (ATC)	26 00 00	
Smoke Detectors (Duct mounted)	26 00 00	23 00 00	26 00 00	23 00 00 (ATC)	26 00 00	
Smoke & Fire/Smoke Dampers	23 00 00	23 00 00	N/A	N/A	N/A	
Smoke & Fire/Smoke Damper Actuators	23 00 00	23 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	2
Fire Dampers	23 00 00	23 00 00	N/A	N/A	N/A	
VAV Boxes	23 00 00	23 00 00	26 00 00	23 00 00 (ATC)	N/A	2
VAV Box Damper Actuator	23 00 00 (ATC)	Box Mfr	23 00 00 (ATC)	23 00 00 (ATC)	N/A	2
VAV Box DDC Controller	23 00 00 (ATC)	Box Mfr	23 00 00 (ATC)	23 00 00 (ATC)	N/A	2

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Hydronic Control Valves	23 00 00 (ATC)	23 00 00	N/A	23 00 00 (ATC)	N/A	1
Hydronic Control Valve Actuator	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	1
Sheet Metal Damper	23 00 00	23 00 00	N/A	N/A	N/A	1
Sheet Metal Damper Actuators	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	1
Electrical Energy Meters	26 00 00	26 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3, 5
Natural Gas Energy Meters	23 00 00 (ATC)	22 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
Domestic Water Submeters	23 00 00	22 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3, 5
HVAC Hydronic Energy Meters	23 00 00	23 00 00 (ATC)	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3, 5
RTU/AHU Outdoor Air Airflow Measuring Stations	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	N/A	6
RTU/AHU Fan Airflow Measuring Stations	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	N/A	6
Duct Mounted Airflow Measuring Stations	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	
DDC Panels	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	4
VFD's at EF's, Pumps (except ECM motor)	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	23 00 00 (ATC)	N/A	
VFDs at RTU/AHU Fans	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	26 00 00	23 00 00 (ATC)	N/A	7
VFDs at RTU/AHU Energy Recovery Wheels	23 00 00 (RTU/AHU Manuf.)	23 00 00 (RTU/AHU Manuf.)	26 00 00	23 00 00 (ATC)	N/A	7
Elevator Hoistway Vent Damper	23 00 00	23 00 00	N/A	N/A	N/A	
Elevator Hoistway Vent Damper Actuator	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Kitchen Energy Management System	Food Service Contractor	Food Service Contractor	26 00 00	23 00 00 (ATC)	26 00 00	
Generator Breeching	26 00 00	26 00 00	N/A	N/A	N/A	
Point-of-use Water Heaters	22 00 00	22 00 00	26 00 00	N/A	N/A	-
Emergency Shower Flow Switch	22 00 00	22 00 00	26 00 00	23 00 00 (ATC)	N/A	8
Kitchen Emergency Gas Valve	22 00 00	22 00 00	26 00 00	26 00 00	26 00 00	
Boiler Breeching	22 00 00	22 00 00	N/A	N/A	N/A	
DHW Breeching	22 00 00	22 00 00	N/A	N/A	N/A	

Notes:

1. Division 23 00 00 and Division 23 00 00 (ATC) Contractors shall fully coordinate all airflow damper and hydronic valves sizes and quantities.
2. Smoke Damper and VAV Box power wiring shall be provided by Division 26 00 00 to junction box locations shown on electrical drawings; Division 23 00 00 (ATC) Contractor shall provide final power wiring from junction box to end device location.
3. Division 26 00 00 Contractor shall provide all line-voltage power wiring required for meters; Division 23 00 00 (ATC) Contractor shall provide all low-voltage power wiring required for meters.
4. Division 26 00 00 shall provide power at main DDC Panel and Junction Box locations throughout the building as indicated on Electrical Plans. Division 23 00 00 (ATC) shall provide power to all other DDC Panels and Control Devices.
5. Wiring from meters to Building Dashboard System shall be BACNet/IP and provided by ATC Contractor.
6. Outdoor airflow and fan airflow measuring station programming shall be provided by ATC contractor.
7. VFDs for AHU/RTU units shall be provided by RTU/AHU manufacture. Internal Power wiring for Fans within AHU/RTU casing shall be provided by Unit Manufacturer and terminated to VFD. Power wiring for VFDs shall be provided by Electrical Contractor.
8. Division 26 00 00 Contractor shall provide all line-voltage power wiring required; Division 23 00 00 (ATC) (ATC) Contractor shall provide all low-voltage power wiring required connecting to the BMS.

PART 2- PRODUCTS

2.01 GENERAL

- A. Product specifications are written in such a manner so as to specify what materials may be used in a particular location or application and therefore does not indicate what is not acceptable or suitable for a particular location or application. As an example: non-metallic sheathed cable is not specified; therefore, it is not acceptable.

- B. For purpose of establishing a standard of quality and not for purpose of limiting competition, the basis of this Specification is upon specified models and types of equipment and materials, as manufactured by specified manufacturers.
- C. In all cases, standard cataloged materials and systems have been selected. Materials such as lighting fixtures specially manufactured for this particular project and not part of a manufacturers' standard product line will not be acceptable. In the case of systems, the system components shall be from a single source regularly engaged in supplying such systems. A proposed system made up of a collection of various manufacturers' products will be unacceptable.
- D. Where Specifications list manufacturers' names and/or "as approved" or "Equal approved by Architect", other manufacturers' equipment will be considered if equipment meets Specification requirements and has all features of the specified items as are considered essential by Architect.
- E. All material shall be new and shall be UL listed.

2.02 RACEWAYS AND FITTINGS

- A. Raceways - General:
 - 1. No raceway shall be used smaller than 3/4 in. diameter and shall have no more than four (4) 90 deg. bends in any one run, and where necessary, pull boxes shall be provided. Only rigid metal conduit or intermediate metal conduit is allowed for slab work. Cable systems, if allowed to be used by other sections of this specification, shall not be used exposed or in slabs, whether listed by "UL" for such use or not.
 - 2. Rigid metal conduit conforming to, and installed in accordance with, Article 344 shall be heavy wall zinc coated steel conforming to American Standard Specification C80-1 and may be used for service work, exterior work, slab work, and below grade level slab, wet locations, and in mechanical rooms for drops down to equipment from elevations below eight feet and also where raceway may be subject to mechanical damage.
 - 3. Intermediate metal conduit conforming to, and installed in accordance with, Article 342, may be used for all applications where rigid metal conduit is allowed by these specifications except where restricted by code.
 - 4. Electrical Metallic Tubing (EMT), conforming to, and installed in accordance with, Article 358 shall be zinc coated steel, conforming to industry standards, may be used in masonry block walls, stud partitions, above furred ceilings, where exposed but not subject to mechanical damage, and may be used for fire alarm work.
 - 5. Surface metal raceways conforming to, and installed in accordance with, Article 386 shall be used where raceways cannot be run concealed in public spaces including corridors, offices, toilets, etc. Every effort shall be made to conceal conduits.
 - 6. Flexible metal conduit shall be used for final connections to recessed lighting fixtures from above ceiling junction boxes and for final flexible connections to motors and other rotating or vibrating equipment. Liquid tight flexible metal conduit shall be used for the above connections which are located in moist locations. All flexible connections shall include an insulated grounding conductor.
 - 7. Rigid non-metallic conduit shall be used for underground electric and telephone services outside the foundation wall and shall be polyvinyl chloride (PVC) schedule 40, 90 deg. C.

8. PVC Schedule 40 may also be used for below slab feeders and circuits within building foundation. Below slab rigid non-metallic conduits do not require concrete encasement. Rigid non-metallic conduits may also be used for exterior feeders and branch circuits. Rigid non-metallic conduits shall not be used in slabs, for elbows that penetrate slabs or thru-foundation walls. Raceways and fittings shall be produced by same manufacturer.
 9. Manufacturers:
 - a. Wheatland Tube Company
 - b. Republic Conduit
 - c. Thomas & Betts
 - d. Carlon
 - e. Or equal
 10. Fittings:
 - a. Provide insulated bushings on all raceways 1 inch diameter or larger.
 - b. Manufacturer's standard fittings shall be used for raceway supports.
 - c. Expansion Fittings: Expansion fittings shall be used where structural and concrete expansion joints occur and shall include a ground strap.
 - d. Couplings for rigid metal and intermediate metal conduit shall be threaded type.
 - e. Threadless fittings for EMT shall be watertight compression type or set-screw type (dry-locations). All fittings shall be concrete tight. No diecast fittings allowed except for raceways larger than 1 inch diameter.
 - f. Cable supports in vertical raceways shall be of the split wedge type. Armored cable supports for vertical runs to be of wire mesh basket design.
 - g. Wall entrance seals shall be equal to O.Z. Gedney type "WSK" or equal.
 - h. Couplings, elbows and other fittings used with rigid nonmetallic conduit shall be of the solvent cemented type to secure a waterproof installation.
 - i. Manufacturers:
 - 1) O.Z. Gedney
 - 2) Crouse Hinds
 - 3) Appleton
 - 4) EFCOR
 - 5) Or equal
- B. PVC coated, threaded conduit shall be used in corrosive environments and where penetrating the slab and exposed. Where penetrating the slab and exposed the PVC coated conduit shall extend to two feet above finished floor.
1. Manufacturers:
 - a. Permacote
 - b. Plasti-Bond
 - c. KorKap
 - d. Or Equal
 2. Conduits for use in Corrosive Environments (apparatus bays, parking garage, garage bays, chemical storage rooms, Salt shed, Brine shed, sallyports etc.):

3. General:
 - a. Scope:
 - 1) The PVC-coated, threaded conduit system is specifically designed to prevent corrosive conditions from causing early replacement of the conduit. All the conduit, fittings, and supporting products shall be provided by the same manufacturer to ensure that a five-year product warranty is achieved.
 - b. Classification and Use:
 - 1) The PVC-coated, threaded conduit system is approved for all applications where rigid metal conduit is permitted. Also, it will replace the need for wider fill around Rigid Metal Conduit (RMC) where judged suitable for the conditions (reference NEC Article 344, II, C).
4. Product:
 - a. PVC-coated, Galvanized Rigid Conduit (GRC) and fittings as manufactured by Plasti-Bond, Perma-Cote, and KorKap. Any deviation will require approval of the specifying engineer or owner and shall meet all the performance standards specified herein and verified by a nationally recognized testing agency.
5. Materials:
 - a. The PVC coated galvanized rigid conduit must be UL Listed and ETL Verified. Both the PVC and Zinc coating must have been investigated by UL as providing primary corrosion protection for the rigid metal conduit. Ferrous fittings for general service locations must be UL Listed with PVC as the primary corrosion protection. Hazardous location fittings, prior to plastic coating must be UL listed. All conduit and fittings must be new, unused material.
 - b. The PVC coated galvanized rigid conduit must be ETL Verified to the Intertek ETL High Temperature H2O PVC Coating Adhesion Test Procedure for 200 hours. The PVC coated galvanized rigid conduit must bear the ETL Verified PVC-001 label to signify compliance to the adhesion performance standard.
 - c. The conduit shall be hot dip galvanized inside and out with hot galvanized threads.
 - d. A PVC sleeve extending one pipe diameter or two inches, whichever is less, shall be formed at every female fitting opening except unions. The inside sleeve diameter shall be matched to the outside diameter of the conduit. The PVC coating on the outside of conduit couplings shall have a series of longitudinal ribs 40 mils in thickness to protect the coating from tool damage during installation.
 - e. Form 8 Condulets shall have a V-Seal tongue-in-groove gasket to effectively seal against the elements. The design shall be equipped with a positive placement feature to ease and assure proper installation. Certified results confirming seal performance at 15 psig (positive) and 25 in. of mercury (vacuum) for 72 hours shall be available. Form 8 Condulets shall be supplied with plastic encapsulated stainless steel cover screws.
 - f. Urethane coating of nominal 2 mil thickness shall be uniformly and consistently applied to the interior of all conduit and fittings. Conduit or fittings with thin or no coating shall be unacceptable.
 - g. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperatures above 30°F (-1°C).
 - h. All female threads on fittings and couplings shall be protected by urethane coating.

- i. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the coated conduit. All U bolts will be supplied with plastic encapsulated nuts that cover the exposed portions of the threads.
- 6. Execution:
 - a. Installation:
 - 1) Installers of the PVC-coated galvanized rigid conduit system must be certified by the manufacturer and be able to present a valid, unexpired certified installer card prior to starting installation. All clamping, cutting, threading, bending, and assembly instructions given during the manufacturer's certified installation training should be vigorously followed.

C. Fiberglass Reinforced Epoxy Conduit

- 1. A complete system of various fittings and adapters of the same material shall be readily available. The conduit shall be available in standard sizes from one (1) inch through six (6) inch diameters in lengths of twenty (20) feet, plus or minus one (1) inch. Each length of conduit shall contain an integral bell end for push-fit, bell and spigot assembly unless specified otherwise.
- 2. Dimensions
 - a. Inside Diameter of conduit shall be as follows:

<u>Size Conduit</u>	<u>Inside Dimension</u>	<u>Wall Thickness(Normal)</u>
1"	1.00"	0.070"
2"	2.00"	0.070"
3"	3.00"	0.070"
4"	4.00"	0.070"
5"	5.00"	0.095"
6"	6.00"	0.095"

- b. All conduit shall be designated as 'heavy wall' and minimum wall thickness for a 5 and 6-inch conduit shall be 0.095 inches.
- 3. Fittings
 - a. A complete range of general-purpose fittings such as bends, sleeves, and caps, shall be available to interconnect the conduit. Special expansion joints and wobble couplings shall be available in conjunction with bridge installations. There shall be a selection of adapters enabling the conduit to be connected to threaded steel, PVC, asbestos, cement, and bituminous fiber conduit systems.
 - b. Sleeve couplings shall be available for joining conduits with epoxy adhesive. They shall be available in all sizes.
 - c. Bend fittings shall be available in 11-1/4, 22-1/2, 45, and 90 degrees with radius of bend varying to the size of conduit.
- 4. Adhesive

- a. Use of sleeve couplings requires the need for epoxy adhesive. It shall be supplied by the manufacturer of the conduit and shall have excellent pull out strength per the following table:

<u>SIZE (Inches)</u>	<u>ADHESIVE JOINT PULLOUT STRENGTH (LBS.)</u>
1	1000
2	2000
3	3000
4	4000
5	5000

5. Materials

- a. Conduits and fittings shall be composed of glass filaments encapsulated in an epoxy matrix with a carbon black pigment homogeneously dispersed throughout the epoxy glass matrix for ultra- violet ray protection. Conduit and fittings shall be filament wound.

6. Physical properties

- a. Conduits shall possess the following minimum physical properties:

- 1) Specific Gravity = 1.94 ASTM D792
- 2) Barcol Hardness = 52 ASTM D2583
- 3) Glass Content = 68% API SPEC. 5 LR
- 4) Water Absorption = less than 1% (max.) ASTM D570

7. Surface finish

- a. The outside surface of the conduit shall be smooth and normal with good filament winding practice and shall be limited in magnitude such that the O.D. will be in allowable limits. The value of this shall be no greater than 2,000 microinches on a surface roughness scale.
- b. The inside surface of the conduit shall have a surface roughness less than 125 microinches with an average value of about 63 microinches.
- c. Color for exterior conduit shall be black.

8. Mechanical properties

a. Tensile strength, Longitudinal:	11,000 PSI per ASTM D2105
b. Compressive Strength, Axial:	12,000 PSI per ASTM D695
c. Ultimate Elongation:	2% per ASTM D2105
d. Modulus of Elasticity in Tension:	1,250,000 PSI per ASTM D2105

9. Impact resistance

- a. Impact resistance shall conform to ASTM D2444 and shall be no less than:

<u>Size</u>	<u>Average Impact Resistance</u>
1	25
2	40
3	70
4	80
5	140
6	300

- b. Test shall be conducted on size 1-5 inch with a 20 pound Tup B. The 6 inch size will use a 40 pound Tup B.

10. Electrical properties

a.	Dielectric strength:	500 volts/mil per ASTM D149
b.	Dissipation factor:	0.5% average at room temperature 110V, 60
	HZ per ASTM D150	
c.	Thermal conductivity:	2.0 BTU/HR./SQ. FT. DEG./Inch
	Coefficient of Linear Thermal	
d.	Expansion:	1.25 x 10 inch/inch/degree F per ASTM
	D696	
e.	Temperature Range:	Minus -40F to plus 230F Continuous Service
	Temperature:	230 F minimum Flammability: HB
	Rating per U.L. 94	

11. Co-efficient of friction

- a. With dry conduit and non-lubricated cable, co-efficients of friction for various types of cable shall be as follows:

Cross Linked Polyolefin Cable	0.233 + 0.02
PVC Jacketed Cable	0.385 + 0.06
Concentric Neutral Cable	0.160 + 0.03
Neoprene Jacketed Cable	0.531 + 0.04

12. Water absorption

- a. Conduit water absorption shall not contain chlorine gas in excess of trace levels and always less than safe limits imposed by O.S.H.A. in the event of cable faults, the conductors shall not adhere to the conduit or fittings.

13. Execution

- a. Install all items in their proper locations as shown on the Contract Drawings, rigid and secure, plumb and level, and in true alignment with related and adjoining work. Do not weld electrical materials for attachment or support.
- b. Furnish anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the job site to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.
- c. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts and angles as required to set and connect rigidly the work.
- d. Control erection tolerance requirements to not impair the strength, safety, serviceability, or appearance of the installations, as approved by the Engineer. Determine exact location of conduit. Route all conduit parallel to building lines.
- e. The trade size, type and general routing and location of conduits, raceways, and boxes shall be as indicated.
- f. Install exposed conduit so as to avoid conflicts with other work. Install horizontal raceway close to the ceiling or ceiling beams, and above water or other piping whenever possible.
- g. Install individual conductors in conduits, raceways, cable trays, ducts, and trenches and multiple-conductor sheathed cables as shown on the Contract Drawings to complete the wiring systems.
- h. Install switches, receptacles, special purpose outlets, and cover plates complete in a neat manner in accordance with the NEC and local electrical codes.

D. Outlets, Pull and Junction Boxes:

1. Outlets:

- a. Each outlet in wiring or raceway systems shall be provided with an outlet box to suit conditions encountered. Boxes installed in normally wet locations or surface mounted shall be of the cast-metal type having hubs. Concealed boxes shall be cadmium plated or zinc coated sheet metal type. Old work boxes with Madison clamps not allowed in new construction. Thru the wall boxes are not permitted.
- b. Each box shall have sufficient volume to accommodate number of conductors in accordance with requirements of Code. Boxes shall not be less than 1-1/2 in. deep unless shallower boxes are required by structural conditions and are specifically approved by Architect. Ceiling and bracket outlet boxes shall not be less than 4 in. octagonal except that smaller boxes may be used where required by particular fixture to be installed. Flush or recessed fixtures shall be provided with separate junction boxes when required by fixture terminal temperature requirements. Switch and receptacle boxes shall be 4 in. square or of comparable volume.
- c. Far side box supports shall be Caddy J-1A.
- d. Manufacturers:
 - 1) Appleton
 - 2) Crouse Hinds
 - 3) Steel City
 - 4) RACO
 - 5) Or equal

2. Pull and Junction Boxes: Where indicated on plans, and where necessary to terminate, tap off, or redirect multiple raceway runs or to facilitate conductor installation, furnish, and

install appropriately designed boxes. Boxes shall be fabricated from code gauge steel assembled with corrosion resistant machine screws. Box size shall be as required by Code.

Boxes in moist or wet areas shall be galvanized type. Boxes larger than 4-11/16 inches' square shall have hinged covers. Boxes larger than 12 inches in one dimension will be allowed to have screw fastened covers, if a hinged cover would not be capable of being opened a full 90 degrees due to installation location.

Manufacturers:

- a. Hoffman
- b. Keystone
- c. Lee Products Co.
- d. McKinstry Inc.
- e. Or equal

2.03 CONDUCTORS

- A. All conductors shall be a minimum size of #12 AWG except for control wiring and fire alarm wiring where #14 AWG may be used. For all exit sign circuits, exterior lighting circuits and also where distance from panelboard to first outlet exceeds 100 ft. @ 120 volts, #10 AWG shall be minimum size wire allowed. All feeder and branch circuit conductors shall be color coded as follows:

1.	208Y/120V	Phase A	Black
2.	208Y/120V	Phase B	Red
3.	208Y/120V	Phase C	Blue
4.	480Y/277V	Phase A	Brown
5.	480Y/277V	Phase B	Orange
6.	480Y/277V	Phase C	Yellow
7.	Grounded Conductor	120/208	White
		277/480	Grey
8.	Equipment Ground	120/208	Green
		277/480	Green with Yellow Trace
9.	Grounded Conductor	120/208	White
10.	Equipment Ground	120/208	Green
11.	Isolated Ground	120/208	Green with Orange Trace

- B. All conductors not installed in accordance with color scheme shall be replaced. All conductors larger than #6 AWG must be identified with colored tape.
- C. Comply with CMR 527, Massachusetts Electrical Code.

- D. Comply with Underwriter's Laboratories (UL) standards:
 - 1. UL 4: Armored Cable.
 - 2. UL 62: Flexible Cord and Fixture Wire.
 - 3. UL 83: Thermoplastic-Insulated Wires and Cables.
 - 4. UL 486A: Wire Connectors and Soldering Lugs for Use with Copper Conductors.
 - 5. UL1569: Metal -Clad Cables.
- E. Comply with NEMA WC-5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- F. Connections throughout the entire job shall be made with solderless type devices.
 - 1. For #10 AWG and smaller: spring type.
 - 2. For #8 AWG and larger: circumferential compression type.
 - 3. Acceptable manufacturers:
 - a. 3M "Scotchlock"
 - b. IDEAL "Wingnut"
 - c. BURNDY
 - d. MAC
 - e. Or equal
 - 4. Any splices made up in ground mounted pull boxes shall be resin cast waterproof type or waterproof pressure type, as manufactured by King Technology, St. Louis, MO.
- G. All conductors shall have heat/moisture resistant thermoplastic insulation type THHN/THWN (75 degrees C) except as follows:
 - a. In sizes #1 AWG and larger: Crosslinked polyethylene insulation type XHHW (75 degrees C – 90 degrees C) may be used.
 - b. Fire alarm system conductors shall be #14 AWG, type THHN, solid. Color coding of fire alarm conductors shall be in accordance with fire codes.
 - c. Fixture whips #16AWG type "SF".
- H. Stranded conductors for all wiring systems except fire alarm will be allowed if installed and terminated as specified under Execution Section.
- I. Mineral-Insulated Metal-Sheathed Fire-Resistive Cables (Type MI) - Cables shall consist of a factory assembly of one or more solid copper conductors insulated with highly-compressed magnesium oxide and enclosed in a seamless, liquid-and-gas-tight continuous copper sheath. Cables shall be rated for 600 volts and less. Cables shall comply with Article 332 of the National Electrical Code. Cables shall be classified by Underwriters Laboratories, Inc. as having a 2-hour fire resistive rating. Cable terminations shall be made with UL listed mineral-insulated cable fittings. Approved Manufacturer - Pyrotex USA, Inc. or approved equal.
- J. Type MC Cable may be used for concealed branch circuits in hollow spaces where allowed by code if installed and terminated as specified under Execution Section. Armor shall be galvanized steel and shall be UL listed for 2 hour fire wall penetration. Aluminum armor is not acceptable.
- K. Type MC Cable may also be used for fire alarm where concealed and allowed by Code. Armor shall be red.

L. Low energy fire alarm cable may be used for fire alarm when concealed and allowed by code.

M. Acceptable manufacturers:

1. AFC Cable Systems
2. American Wire & Cable
3. Cerro
4. Cornish
5. Crescent
6. General Cable
7. Okonite
8. Or equal

N. Installation of conductors and cables

1. Install all power and 120 volt control wire and cable in approved raceways. When low tension wiring is run exposed, install it in conduit. Plenum rated low tension cable may be used for installation above suspended ceilings where it is allowed by the Code and is allowed in the specification for the specific system.
 - a. Wire Size:
 - 1) Install minimum No. 12 AWG for power and lighting circuits.
 - 2) Install minimum No. 10 AWG for 120 volt 20 ampere branch circuits of 75 feet to 150 feet length, and minimum No. 8 AWG for the circuits of 150 feet to 250 feet unless otherwise shown on the drawings or required by the equipment shop drawings.
 - 3) Install minimum No. 10 AWG for 277 volt 20 ampere branch circuits of more than 150 feet unless otherwise shown on the drawings.
2. Metal clad cable type MC may be used for branch circuit wiring above suspended ceilings and for device wiring in the metal stud partitions. MC cable shall not be used for a termination at the panels (homeruns) and where they run exposed. Any wiring associated with Smoke control systems can not be installed in MC cable as it does not meet 780 CMR Section 909.12.1.
3. Bundle conductors #10 and smaller in branch circuit panelboards, signal cabinets, signal control boards in switchboards and motor control centers.
4. Homerun Circuits:
 - a. Follow homerun circuit numbers shown on the drawings to connect circuits to the panelboards. Where homerun circuit numbers are not shown on the drawings, divide similar types of connected loads among phase busses so that currents in each phase are within 10% of each other during normal usage.
 - b. Wire multi-wire branch circuit homerun with two or three single phase and one common neutral conductor to a panel in a such manner that each phase circuit is fed from the adjacent circuit breakers. Do not combine circuits so that any homerun has more than three circuits (total of five wires) installed in one conduit, unless the circuit conductors are de-rated in strict accordance with the referenced Electrical Code.
 - c. Branch circuit wiring in the classrooms, laboratories and offices shall be provided with a dedicated neutral conductor for each phase conductor.

5. Properly group feeders, branch circuit and auxiliary system wiring passing through pull boxes and/or being made up in panelboards; neatly bind each group of wires together with plastic cable ties, and trim loose ends of the ties.
6. Peel branch circuits and auxiliary system wiring out of the wiring gutters at the terminal cabinet and panels at 90 degrees to circuit breakers and terminal lugs before making connections.
7. Color code conductors No. 6 AWG and larger by applying colored plastic tape at ends and where connections and splices are made. Wrap tape around the conductor three complete turns.
8. Splices and Terminations:
 - a. Make splices and joints by means of UL-listed, solderless connectors rated 600 volt, of sizes and types required by manufacturer's recommendations, with temperature ratings equal to that of wire.
 - b. Attach copper wire to panelboards, switchboards, disconnect switches and other electrical equipment by means of bolt-on lugs with hex screws. Properly size lugs; do not cut strands from a conductor in order to fit conductor into a lug.
 - c. Connectors for cables 250 MCM and larger shall have two clamping elements and terminals for bus connections shall have two bolt holes.
9. Identification: Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems." Label feeder and branch circuits in pull and junction boxes, handholes and at cable terminations in the panelboards, motor control centers, and switchboards. Use non-ferrous tags or labels stamped or printed to correspond with markings on the drawings or marked so that feeder or cable may be identified readily. If suspended tags are provided, attach with nylon line or cable lacing.
10. Connect branch circuits to the breakers in multi-phase panelboards required to balance loads.
11. Provide handle ties for multiwire branch circuits as required in the NEC
12. Low Tension Cables: Provide separation from power wiring and lighting fixtures as follows:
 - a. Lighting fixtures - at least 6 inches.
 - b. Power branch circuit wiring with MC type cable - at least 12 inches.
 - c. Power branch circuit wiring in metal conduit - at least 6 inches.
13. When low-tension cables are not in conduit or trays, support cables from the deck and/or beams, spacing supports no farther apart than 6 ft.-0 in. on center. Provide hangers, clips or other approved method of grouping the cables and keeping them away from other systems. Take care to ensure that ties, clips and other support devices do not compress the cable or damage cable insulation; use J-hooks whenever possible.
14. Cable Supports:
 - a. Provide cable supports for vertical feeders required by the referenced Electrical Code.
 - b. Support vertical feeders at each floor level.
 - c. Support and secure metal-clad cable Type MC at intervals not exceeding 6 feet and within 12 inches from every outlet box, junction box or cabinet.
 - d. Support metal clad cable Type MC with cable supports equal to Caddy WMX-6, MX-3, and clamps equal to Caddy 449. Where cables are supported by the structure and only need securing in place, then cable ties will be acceptable.
15. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

16. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
17. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
18. For wiring in high temperature areas or high temperature equipment (i.e. boiler rooms, water heaters/boosters), furnish conductors for 90°C dry and wet rating.

2.04 ACCESS PANELS

- A. Coordinate and Furnish access panels for access to concealed junction boxes and to other concealed parts of system that require accessibility for operation and maintenance. In general, electrical work shall be laid out so access panels are not required.
- B. Access panels shall be located in a workmanlike manner in closets, storage rooms, and/or other non-public areas, positioned so that junction can be easily reached and size shall be sufficient for purpose (minimum size 12 in. x 12 in.). When access panels are required in corridors, lobbies, or other habitable areas, they shall be located as directed by the Architect. Submit layout and locations for approval.
- C. Access panels once coordinated with the architect and the G.C. shall be furnished by this trade contractor to the G.C. for installation. Coordinate all locations so that the finish trades can locate the rough openings appropriately.
- D. Furnish Access panels in compliance with Section 08 31 13.
- E. Furnish access panel shop drawings.

2.05 SLEEVES, INSERTS, AND OPENINGS

- A. Sleeves: Provide sleeves of proper sizes for all openings required in concrete floors and walls. Sleeves passing through floors shall be set with top of sleeve 1 in. above finished floor. Core drilling will also be acceptable if in accordance with any structural standards. Any unsleeved openings shall be waterproofed.
- B. Inserts: Provide inserts or other anchoring devices in concrete and masonry construction as required to support raceways and equipment.
- C. Openings: Where an opening is required in concrete slabs to allow passage of a multitude of raceways, give adequate notice to General Trades Contractor so he may box out opening in form work.
- D. Any openings through fire rated surfaces shall be closed off with fireproofing materials providing the same rating as the surface penetrated.
 1. Manufacturers:
 - a. Specified Technologies Inc.
 - b. Thomas & Betts
 - c. International Protective Coatings Corp.
 - d. 3M Fire Protection Products

e. Or equal

2.06 FLOOR OUTLETS (FLUSH TYPE)

- A. Section includes flush floor boxes equal to Wiremold RFB Series. Provide appropriate floor box model that meets the intent of what is shown on the drawings.
- B. Quality Assurance
 1. Electrical Raceways and Components: Comply with requirements of applicable local codes, NEC, UL, and NEMA Standards pertaining to raceways and components. Listed and labeled in accordance with NFPA 70, Article 100.
- C. Floor Boxes
 1. RFB4 and RFB4-4DB Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 12-3/4" L x 10" W x 3-7/16" H [324mm x 254mm x 87mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The RFB4 Series Box shall permit tunneling from end power compartment to end power compartment. The RFB4-4DB Series Box shall permit tunneling from adjacent or opposite compartments. Two (2) of the four (4) compartments shall have a minimum wiring capacity of 16.4 cu in [269cu cm], one (1) compartment shall have a minimum capacity of 32.3 cu in [529cu cm], and one (1) compartment shall have a minimum capacity of 50 cu in [820cu cm]. Four (4) compartments shall have a minimum of two (2) inches of space behind the device plates. The box shall include the following number of conduit knockouts: one (1) 1/2-inch [12.7mm], three (3) 1-inch [25mm], six (6) 3/4-inch [19.1mm], and six (6) 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [47.7mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment.

The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
 2. RFB4-CI-1 and RFB4-CI-NA Series Floor Boxes: Manufactured from cast-iron and approved for use on grade and above grade floors. The box shall be 14-1/2" L x 11-7/8" W x 3-7/16" H [368mm x 302mm x 87mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles and/or communication services. The box shall permit tunneling from adjacent or opposite compartments. Two (2) of the four (4) compartments shall have a minimum wiring capacity of 27 cu in [443cu cm], and two (2) compartments shall have a minimum wiring capacity of 36 cu in [590cu cm]. Four (4) compartments shall have a minimum of two (2) inches of space behind the device plates. The box shall include the following number of conduit hubs: four (4) 1-inch [25mm] and four (4) 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [48mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

3. RFB4-SS Series Floor Boxes: Manufactured from stamped-steel and approved for use on above grade floors. The box shall be 13-5/8" L x 10" W x 2-7/16" H [346mm x 254mm x 62mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the four (4) compartments shall have a minimum wiring capacity of 15.7 cu in [257cu cm] and two (2) compartments shall have a minimum wiring capacity of 31.2 cu in [511cu cm]. Four (4) compartments shall have a minimum of two (2) inches of space behind the device plates. The box shall contain the following number of conduit knockouts: two (2) 1/2-inch [12.7mm], six (6) 3/4-inch [19.1mm], and eight (8) 1-inch [25mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [48mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
4. RFB4E Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 13-1/8" L x 13-1/8" W x 4-1/16" H [333mm x 333mm x 103mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The box shall permit feed through removable barriers from adjacent compartments. Four (4) compartments shall have a minimum wiring capacity of 75 cu in [1230cu cm]. Four (4) compartments shall have a minimum of 3-1/2 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: six 3/4-inch [19.1mm], ten (10) 1-inch [25mm], and eight (8) 1-1/4-inch [32mm]. The box shall have two removable knockout plates that can be replaced with a 2-inch trade size conduit hub (2HUB). The box shall be fully adjustable, providing a maximum of 2-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
5. RFB4E-OG Series Floor Boxes: Manufactured from stamped steel and painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and approved for use on grade and above grade floors. The box shall be 13-1/8" L x 13-1/8" W x 4-1/16" H [333mm x 333mm x 103mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The box shall permit feed through removable barriers from adjacent compartments. Four (4) compartments shall have a minimum wiring capacity of 75 cu in [1230cu cm]. Four (4) compartments shall have a minimum of 3-1/2 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: six 3/4-inch [19.1mm], ten (10) 1-inch [25mm], and eight (8) 1-1/4-inch [32mm]. The box shall have two removable knockout plates that can be replaced with a 2-inch trade size conduit hub (2HUB). The box shall be fully adjustable, providing a maximum of 2-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
6. RFB6 Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 3-1/4" H [333mm x 317mm

x 83mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

7. RFB6-OG Series Floor Boxes: Manufactured from stamped steel and painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and approved for use on grade and above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 3-1/4" H [333mm x 317mm x 83mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment.

The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

8. RFB6E Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 4" H [333mm x 317mm x 102mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments through 1-1/4-inch grommet openings. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate

Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

9. RFB6E-OG Series Floor Boxes: Manufactured from stamped steel and painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and approved for use on grade and above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 4" H [333mm x 317mm x 102mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates, and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

D. Activation Covers

1. FloorPort FPCT, FPBT, and FPFFT Series Covers: Manufactured of die-cast aluminum or die-cast zinc, and available in brushed aluminum finish and powder-coated paint finishes (black, gray, bronze, nickel and brass). Activation covers shall be available in flanged and flangeless versions. Covers shall be available with options for tile or carpet inserts, or flush covers. The cover's hinge shall allow for the cover to open 180 degrees. The furniture feed covers shall come equipped with one (1) 1-inch trade size screw plug opening and one (1) combination 1-1/4-inch and 2-inch trade size screw plug.
 - a. Flanged covers shall be 7-3/4" L x 6-9/16" W [197mm x 167mm].
 - b. Flangeless covers shall be 6-3/4" L x 5-9/16" W [171mm x 142mm].
2. 6CT, 6CTC, 6CFFTC, 8CTC, and 8CT Series Covers: Manufactured of die-cast aluminum alloy and available in powder-coated gray, black, brass, nickel or bronze finish. The covers shall be available in carpet and tile versions. Provide covers with two (2) gaskets (one (1) for carpet and one (1) for tile) to go under the trim flange to maintain scrub water tightness. The activation cover for the 8CTC and 8CT series shall be 9-1/4-inch [235mm] in diameter. The activation cover for the 6CT and 6CTC series shall be 7-1/4-inch [184mm] in diameter and the activation cover for the 6CFFTC series shall be 7-3/4-inch [197mm] in diameter. The carpet covers shall be surface mounted and the tile covers shall be flush with the finished floor covering. The covers shall have spring loaded slides to allow cables to egress out of the unit and maintain as small an egress opening as possible.
3. The covers shall have been evaluated by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, terrazzo, wood, and carpet covered floors.

E. Communication Modules Mounting Accessories

1. The floor box manufacturer shall provide a complete line of faceplates and bezels to facilitate mounting of UTP, STP (150 ohm), fiber optic, coaxial, and communication devices. The box shall provide a series of device mounting plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, and other open system devices.

F. Installation

1. Strictly comply with manufacturer's installation instructions and recommendations and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.
2. Mechanical Security: Raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer's installation sheets.
3. Accessories: Provide accessories as required for a complete installation, including insulated bushings and inserts where required by manufacturer.
4. Unused Openings: Close unused box openings using manufacturer's recommended accessories.
5. Provide a minimum concrete pour depth of 3-7/16-inch [87mm] plus 1/16-inch [1.6mm] above the top of the box for the RFB4, RFB4-4DB, RFB2, and the RFB2-OG Series Boxes; 2-7/16-inch [62mm] plus 1/16-inch [1.6mm] for the RFB4-SS and RFB2-SS Series Boxes; and 3-7/16-inch [87mm] plus 13/16-inch [21mm] above the top of the box for the RFB4-CI-1, RFB6, and RFB6-OG Series Boxes; and 4-1/16-inch [103mm] above the top of the RFB4E and RFB4E-OG Series Boxes; and 4-inch [102mm] above the top of the RFB6E and RFB6E-OG Series Boxes. Provide the box with four (4) locations to accommodate leveling for pre-concrete pour adjustment and include four (4) leveling screws for the pre-pour adjustment.

G. Poke-Thru Assembly

1. Floor Fitting
 - a. The floor fitting shall consist of an insert and an activation cover. Floor fitting shall accommodate power and communications services in a single unit. Floor fitting shall have one ¾ in. trade size channel for power and one 2" trade size channel for communication cabling. Floor fitting shall consist of intumescent fire stop material to maintain the fire rating of the floor slab and UL Listed with a fire rating of 1, 1½, & 2 hours in an unprotected reinforced concrete floor or a 1 or 2 hour rating in floors employing steel floor units and concrete topping. The floor fitting shall be suitable in concrete floor thicknesses of 2.5 in. or greater. The insert shall have 12 installation barbs that will hold the poke-thru device in the floor slab without additional fasteners.
2. Insert Body
 - a. The insert body shall allow the devices to be recessed 3.5-inches, or 2.25-inches with the use of 1 ¼ in. supplied stand-offs. There shall be complete separation of channels allowing for individual separation of power and communications services. There shall be one channel arranged such that communication cables can be conduit protected and connected with a 2-inch trade size openings to accept both rigid and flexible conduit connectors. The inserts shall consist of multiple compartments that

allow for up to 2 duplex receptacles that can be wired in configurations including standard receptacles, isolated ground or up to 12 communication ports.

3. Activation Cover/ Flange Assembly
 - a. Activation covers and Flange shall be manufactured of die-cast aluminum alloy and be capable of being plated in brushed brass, satin nickel, and bronze finish, lacquer coated brushed aluminum or powder-coated in , black, finishes. Flange shall be suitable for either carpet, tile, terrazzo and wood covered floors. Flange shall include a gasket adhered to the top inside surface to maintain scrub water tightness with sub plates. Flange shall include a gasket for assembly against the floor to maintain scrub water tightness. Cover assembly shall provide a single hinged access doors that rotate 180 degrees flush with flange and incorporate foam gaskets to maintain scrub water tightness by preventing water, dirt, and debris from entering the power and communication compartment. Cover assembly shall feature cable access doors which secure to the underside of the closed cover that allow each cable access door to be opened and closed independently
4. Communication Modules Mounting Accessories
 - a. The poke-through manufacture shall have available modular inserts to facilitate mounting UTP (including Category 5, 5e, 6, 6a), STP, fiber optic, coaxial, and data/communications devices. The S1R6 series shall accommodate Extron MAAP or Extron AAP adapter plates. Where indicated provide connectivity outlets and modular inserts by Hubbell or approved equal.

H. Furniture Feed Poke thru devices

1. Poke-Through Assemblies:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - b. Hubbell.
 - c. Pass & Seymour.
 - d. Thomas & Betts Corporation.
 - e. Wiremold
 - f. Or equal
2. Classification and Use: Furniture feed poke-thru devices shall have been examined and tested by Underwriters Laboratories Inc. to meet UL514A and/or UL514C and Canadian Standard C22.2, No. 18-98 and bear the U.S. and Canadian UL Listing Mark. Furniture poke-thru devices shall also have been tested by Underwriters Laboratories Inc. and Classified for fire resistance and bear the U.S. and Canadian UL Classification Mark. Poke-thru devices are approved for use in recessed and flush floor construction and meet and exceed the UL scrub water exclusion test.
 - a. Devices shall be classified for use in 1-, 1-1/2-, or 2-hour rated, unprotected reinforced concrete floors and 1-, 1-1/2-, or 2-hour rated floors employing unprotected steel floor units and concrete toppings (D900 Series designs), or concrete floors with suspended ceilings. Fire resistive designs with suspended ceilings shall have provisions for accessibility in the ceiling below the poke-thru fittings.
 - b. These devices are not suitable for wet or damp locations, or other areas subject to saturation with water or other liquids such as commercial kitchens.

- c. Floor boxes shall be suitable for use in air handling spaces in accordance with Section 300-22(c) of the National Electrical Code.

3. MATERIALS

- a. RC7AFFTC Flush Furniture Feed Poke-Thru Assembly for power: Consists of an insert and activation cover. Overall poke-thru assembly length shall be 16-1/2 in. [419mm].
- b. Insert: Insert body shall have the necessary channels to provide complete separation of power and communication services. There shall be one 3/4-inch trade size channel for power and two 1/2-inch trade size channels for communication cabling. The channels shall be arranged such that communication cables can be conduit protected and connected to the insert body using a die-cast zinc conduit connector with two 1/2-inch trade size threaded openings to accept both rigid and flexible conduit connections.
- c. The body will consist of an intumescent fire stop material to maintain the fire rating of the floor slab. The intumescent material will be held securely in place in the insert body and shall not have to be adjusted to maintain the fire rating of the unit and the floor slab. Insert shall have a spring-steel retaining ring that will hold the poke-thru device in the floor slab without additional fasteners. The poke-thru insert shall also consist of one 3/4-inch trade size conduit stub and one 1-1/2-inch trade size conduit stub that are connected to the insert body. There shall also be a 24.5 cu in [402ml] stamped steel junction box for wire splices and connections. The stamped steel junction box shall also contain the necessary means to electrically ground the poke-thru assembly.
- d. Activation Cover: The activation cover shall provide three conduit openings to feed modular furniture applications and provide a flush appearance. The activation cover trim flange shall be one-piece and be manufactured of forged aluminum alloy and be capable of being powder coated or plated. Coated finish is to be textured, two-stage epoxy paint in gray or black. Activation cover trim flange shall also be available in a solid brass forging and a die cast brushed aluminum finish. Aluminum and brass finish shall be a brushed finish with a lacquer sealant. The activation cover shall be seven inches [178mm] in diameter. A gasket is attached to the underside of the trim flange assembly to maintain scrub water tightness by preventing water, dirt, and dust from entering the power and communication compartments.
- e. The activation cover insert shall provide one 3/4-inch NPSM threaded opening for power and two 1/2-inch NPSM threaded openings for communication to feed modular furniture workstations. Each activation cover shall also be supplied with one 3/4-inch trade size and two 1/2-inch trade size threaded conduit connectors and one (1/4-inch trade size and one 3/4-inch trade size and two 1/2-inch trade size conduit closure plugs.
- f. RC9AM2TC Furniture Feed Poke-Thru Assembly for data: Consists of an insert and activation cover. Overall poke-thru assembly length shall be 10 inches [254mm].
- g. Insert: There shall be one 2-inch trade size channel for all power or all communication cabling. The body will also consist of an intumescent fire stop material to maintain the fire rating of the floor slab. The intumescent material will be held securely in place in the insert body and shall not have to be adjusted to maintain the fire rating of the unit and the floor slab. Insert shall have a spring-steel retaining ring that will hold the poke-thru device in the floor slab without additional fasteners.

- h. Activation Cover: The activation cover shall be manufactured of aluminum die-cast alloy and consist of a trim flange and a hexagonal service head. The activation cover shall be capable of being powder coated or plated. Finish shall be textured, two-stage epoxy paint available in a gray or black finish. A gasket is attached to the underside of the activation cover trim flange to maintain scrub water tightness. Trim flange shall have a combination 1-1/4 in. - 2 in. trade size conduit opening and closure plugs. The trim flange shall be seven inches [178mm] in diameter. All power connections must be made in a junction box below (not supplied).

I. Cleaning and Protection

- 1. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.
- 2. Protect boxes and fittings until acceptance.

2.07 WIRING DEVICES

A. Manufacturers:

- 1. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - a. Cooper Wiring Devices.
 - b. Hubbell.
 - c. Leviton.
 - d. Pass & Seymour.
 - e. Or equal

B. Straight Blade Receptacles:

- 1. Duplex Receptacles: Comply with NEMA WD 1, NEMA WD 6 configuration NEMA5-20R, UL 498 and FS W-C-596. Specification grade industrial series, straight-blade, 2 pole 3 wire grounding type, back and side wired, nylon face, rated for 120 volts, 20 amperes. Hubbell No.5362 or equal. Hubbell No.5362WR or equal for weather-resistant listed receptacles. Receptacles that are controlled by an automatic control device shall be marked per NEC with the international power symbol. Provide as indicated on the drawings with one controlled face and split circuit hot tab equal to Hubbell BR20C1 series.
- 2. Ground fault interrupter (GFI) receptacles: Duplex receptacles conforming to UL 943, specification grade heavy duty, feed-through type, rated for 120 volt, 20 amperes, NEMA 5-20R, GFI Class "A" with a sensitivity to leakage 5 milliamps, weather-resistant and tamper-resistant listed. Hubbell No. GF20LA or equal.
- 3. Transient-Voltage Surge-Suppressor (TVSS) Receptacles: Duplex type, NEMA 5-20R configuration, with integral transient-voltage surge protection in a minimum of 3 modes: line-to-ground, line-to-neutral, and neutral-to-ground; listed as complying with UL 1449. Hubbell HBL5362SA or equal.
- 4. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Specification grade, straight-blade, 2 pole 3 wire grounding type, back and side wired. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498. Listed as tamper-resistant with "T" marking. Hubbell BR20TR or equal.
- 5. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498. Straight blade; equipment

- grounding contacts connected only to the green grounding screw terminal of the device, with inherent electrical isolation from mounting strap. Hubbell CR 5253IG or equal.
6. Duplex Receptacles with Integral USB jacks (1) type A and (1) type C USB ports, 125 V, 20 A: Specification grade, straight-blade, 2 pole 3 wire grounding type, back and side wired. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498. "USB" marking indicates USB receptacle duplex grounding type NEMA 5-20R equal to Hubbell USB or equal. Where USB receptacle is utilized and requires GFCI protection provide GFCI circuit breaker.
- C. All standard 15 and 20 ampere, 125 and 250 volt non-locking type receptacles located 5 ft. -6 in. or below within Auditorium, Gymnasium, Pre-schools and elementary school age classrooms, medical clinic areas, dental offices and any other areas that are listed in NEC 406.12 shall be tamper resistant type receptacles whether indicated or not by the "T" marking on the drawings.
- D. Exterior Outlets with Lockable Covers:
1. Provide exterior outlets with lockable covers at all exterior outlet locations. Provide GFCI Circuit Breakers on all branch circuits. Provide in-use weatherproof locking covers with cord retention. Provide Taymac MX3200 for single gang vertical MX3300 for single gang horizontal and MX6200 for double duplex.
 - a. Equal manufacturers
 - 1) RACO
 - 2) Hubbell
 - 3) Or equal
- E. Hazardous (Classified) Location Receptacles:
1. Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper Crouse-Hinds.
 - 2) Appleton Electric.
 - 3) Hubbell.
 - 4) KH Industries.
 - 5) Or equal
- F. Twist-Locking Receptacles:
1. Single Convenience Receptacles, 125 V and 250 V, 20 A: Comply with NEMA WD 1, NEMA WD6 and UL 498. Hubbell HBL2310 (L5-20R), HBL2320 (L6-20R), or equal.
- G. Cord Reels
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell.
 - b. Cooper Crouse-Hinds.
 - c. Appleton Electric.
 - d. KH Industries.

2. Industrial grade retractable power cord reel with the following features:
 - a. Cast Aluminum construction, including mounting base
 - b. 12 position adjustable guide arm
 - c. Adjustable ratchet can be engaged (positive lock) or disengaged (constant tension) as needed
 - d. Adjustable ball stop
 - e. 6' Feeder Cord included
 - f. White powder-coat finish
 - g. Universal mounting overhead, wall or detached from bracket completely.
 - h. Adjustable cable stop.
 - i. Voltage 125 VAC
 - j. Slip Ring Rating 600V/30A
 - k. Payout End Blk Duplex/Duplex Outlet Box
 - l. Feeder End 5-20P
 - m. Max. Amperage 20 Amps
 - n. Gauge/Conductor 12/3
 - o. Cord Length 25 Feet
 - p. Mounting Bracket with 340 deg. pivot base.
 - q. Cord Type/Color SJO/White Cord Reel
 - r. Color White
 - s. Hubbell Model#HBLI25123GF220M1 or equal.
3. For WP Cord Reel provide as follows:
 - a. Hubbell Model#HBLW25123 or equal.
 - b. Hubbell Model#HBLPOB1 receptacle enclosure
 - c. Install two duplex receptacles in receptacle enclosure.
 - d. Provide GFCI type circuit breaker for all WP Cord Reels

H. Snap Switches:

1. Comply with NEMA WD 1 and UL 20.
 2. Switches, heavy duty, side wired, 120/277V, 20A:
 3. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way).
 - b. Hubbell; C1221 (single pole), C1222 (two pole), C1223 (three way).
 - c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way).
 - d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way).
- I. Securely fasten wiring devices in place, plumb, level, and true to finished lines and surfaces.
- J. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- K. Provide gaskets on all wiring device plates where devices are on walls separating conditioned and non-conditioned spaces and exterior walls.
- L. Composition material of wiring devices to be nylon with white finish. Outlets intended for computer use shall be grey finish, outlets on normal-emergency shall be red finish.

M. Wall Plates:

1. Single and combination types to match corresponding wiring devices.
 - a. Plate-Securing Screws: Metal with head color to match plate finish.
 - b. Material for Finished Spaces: White- finish Type 302 stainless steel.
 - c. Material for Receptacles installed on wood paneling: Color to be selected by architect. (receptacle color to match faceplate)
 - d. Material for Finished Spaces installed in concrete: Satin-finished Type 302 stainless steel.
 - e. Material for Unfinished Spaces: Galvanized steel.
 - f. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."
2. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum.

N. Finishes:

1. Color: Wiring device catalog numbers as specified do not designate device color.
 - a. Wiring Devices Connected to Normal Power System: Grey for computer circuits white for convenience receptacles other devices as selected by Architect, unless otherwise indicated or required by referenced Electrical Code or device listing.
 - b. Wiring Devices Connected to Emergency Power System: Red. (For public safety building that the entire building is on emergency power Red receptacles would be for UPS backed up receptacles)
 - c. Isolated-Ground Receptacles: Orange.
 - d. Color to be selected by architect for receptacles installed in wood paneling.

2.08 LIGHTING FIXTURES

A. General

1. Submit the following in accordance with project submittal procedures:
 - a. Catalog Data: Submit catalog data describing luminaires, lamps, and ballasts. Include data substantiating that materials comply with specified requirements. Arrange data for luminaires in the order of fixture designation.
 - b. Performance Curves/Data:
 - 1) Submit certified photometric data for each type of luminaire.
 - 2) Submit supply-air, return-air, heat-removal, and sound performance data for air handling luminaires.
 - c. Drawings: Submit shop drawings for non-standard luminaires.
 - d. Calculations: Submit as requested to support equal product proposals.
 - e. Warranty: Submit warranties for luminaires and for electronic ballasts.
 - f. Substitution Form: Provide cover document for all products being submitted as substitutions to the basis of design product. Document provided should include documented reason for substitution and a spreadsheet comparison of the basis of design product and the substituted product based on the following criteria.
 - 1) Luminaire Efficacy
 - 2) Luminaire Efficiency

- 3) Luminaire Lumens
 - 4) Luminaire Wattage
 - 5) Luminaire Correlated Color Temperature (CCT)
 - 6) Luminaire Source
 - 7) Luminaire Color Rendering Index Value (CRI)
 - 8) LED binning information.
 - 9) Luminaire Dimensional Information
 - 10) Luminaire Construction Materials
 - 11) Luminaire Lensing Material & Thickness
 - 12) Luminaire Driver Operating Voltage
 - 13) Luminaire Driver Manufacturer
 - 14) Luminaire Dimming Option
 - 15) Available Fixture Trim Options
 - 16) Available Fixture Finish Options
 - 17) DLC Compliance
 - 18) DLCP Compliance
 - 19) ES Compliance
 - 20) Declare Compliance
 - 21) BAA Compliance
 - 22) Luminaire IP Rating
 - 23) Luminaire IK Rating
2. All led sources, drivers, and controls shall meet the latest utility company incentive requirements. Refer to the latest program requirements documentation and coordinate with the utility company to ensure compliance.
 3. All lamps, ballasts, led sources, drivers, and controls shall meet the latest utility company incentive requirements. Refer to the latest program requirements documentation and coordinate with the utility company to ensure compliance.

B. Quality Assurance

1. Comply with the National Electrical Code (NEC) and the Massachusetts Building Code (MBC) for components and installation.
2. Provide luminaires listed and labeled by a nationally recognized testing laboratory (NRTL) for the application, installation condition, and the environments in which installed.
3. Use manufacturers that are experienced in manufacturing luminaires, lamps and ballasts similar to those indicated for this Project and have a record of successful in-service performance.
4. Coordinate luminaires, mounting hardware and trim with the ceiling system.

C. Lamps

1. Furnish lamps that comply with requirements specified below and the luminaire schedule on the Drawings.

D. LED Assemblies

1. LED luminaires shall conform to UL 1598 and to UL 8250 – Safety Standard for Light-Emitting Diode (LED) Light Sources for Use in Lighting Products.
2. Products shall be lead and mercury free.
3. Photometric characteristics shall be established using IESNA LM-79-08, IESNA Approved Method for the Electrical and Photometric Measurement of Solid-State Lighting Products.
4. Color characteristics of LED luminaires shall be as follows in accordance with ANSI C78.377 – Specifications for the Chromaticity of Solid State Lighting Products.
5. LED and driver cooling system shall be passive and shall resist the buildup of debris.
6. LED luminaire output after 50,000 hours of operation shall be not less than 70 percent of the initial lumen output when determined in accordance with IESNA LM-80-08 – IESNA approved Method for Measuring Lumen Maintenance of LED Lighting Sources.
7. LED source package electrical characteristics:
 - a. Supply voltage: 120 V, 208 V, 240 V, 277 V, or 480 V as indicated on the Drawings. Provide step-down transformers if required to match driver input voltage rating.
 - b. Total harmonic distortion (current): Not more than 10 percent
 - c. Power factor: Not less than 90 percent
 - d. RF interference: Meet FCC 47 CFR Part 15/18
 - e. Transient protection: IEEE C62.41 Class A.
8. All LED Assemblies shall be provided by Osram, Phillips, GE, or equal.

E. Extra Materials

1. Furnish the following extra materials matching products installed. Package with protective covering for storage and identify with labels describing contents.
 - a. Two of LED source drivers of each fixture type.
 - b. One (louver and lens of each fixture type).
 - c. Ten percent of single faced exit signs, but no fewer than ten. Include 100' of type MC cable branch circuiting and installation labor.
 - d. Ten percent of double faced exit signs, but no fewer than five. Include 100' of type MC cable branch circuiting and installation labor.

F. Interior General:

1. Furnish interior luminaries that comply with requirements specified below, indicated on the Drawings to meet conditions of installation.
2. Metal parts shall be free from burrs and sharp corners and edges.
3. Metal components shall be formed and supported to prevent sagging and warping.
4. Steel parts shall be finished with manufacturer's standard finish applied over a corrosion-resistant primer. Finish shall be free from runs, streaks, stains, holidays or defects.
5. Doors and frames shall be smooth operating and free from light leakage under operating conditions. Relamping shall be possible without the use of tools. Doors, frames, lenses and diffusers shall be designed to prevent accidental falling during relamping and when secured in the operating position.
6. Luminaires shall have minimum reflecting surface reflectance as follows unless specified otherwise on the Drawings:
 - a. White Surfaces: 85 percent

- b. Specular Surfaces: 83 percent
 - c. Diffusing Specular Surfaces: 75 percent
- 7. Lenses, diffusers, covers and globes shall be 100 percent virgin acrylic unless specified otherwise on the Drawings. Lenses shall have 0.125 inch minimum thickness. Lenses for troffers shall be injection molded.
 - 8. Luminaires shall conform to UL 1598 - *Luminaires*. Provide product with damp location listing or wet location listing by installation location.

G. Interior Accessories

- 1. Provide stud supports, mounting brackets, frames, plaster rings and other accessories required for luminaire installation.
- 2. Furnish hangers as specified below by conditions of installation:
 - a. Stem hangers shall be made of 1/2-inch steel tubing with 45 degrees swivel ball hanger fitting and ceiling canopy. Finish the same as the luminaire.
 - b. Rod hangers shall be made of 1/4 inch threaded zinc-plated steel rod.
- 3. Use NRTL-listed T-bar safety clips for lay-in luminaires.

H. Interior Installation

- 1. Install interior lighting system in accordance with the NEC, manufacturer's installation instructions, approved shop drawings, and NECA National Electrical Installation Standards.
- 2. Have the manufacturer's installation instructions available at the Project site.
- 3. Mounting heights specified or indicated on the Drawings are to the bottom of the luminaire for ceiling-mounted fixtures and to the center of the luminaire for wall-mounted fixtures.
- 4. Where the ceiling forms the protective membrane of a fire resistive assembly, install protective coverings over luminaires in accordance with NRTL requirements.
- 5. Install slack safety wires as described below for luminaires in or on suspended ceilings.
 - a. Wire shall be minimum 12 gage galvanized soft annealed steel wire conforming to ASTM A641.
 - b. Attach wire to the building structure directly above the attachment point on the box or luminaire; make trapezes of framing channel material to span obstacles
 - c. Secure wire(s) at each end with not less than three tight turns in 1-1/2 inch.
- 6. Support pendant-mounted or cable-supported luminaires directly from the structure above using a 9 gage wire or an approved alternate support without using the ceiling suspension system for direct support.
 - a. Install seismic restraints for pendant-mounted and cable-supported luminaires.
 - b. Pendants, rods, cables, or chains 4 ft or longer shall be braced to prevent swaying using three cables at 120 degrees separation.
- 7. Connect luminaires in suspended ceilings using 6 ft. lengths of flexible wiring method arranged accommodate not less than 4 inch of differential seismic movement in any direction.

I. Interior Quality Control

1. Make electrical connections, clean interiors and exteriors of luminaires, install lamps, energize and test luminaires, inspect interior lighting system, and deliver spare parts in accordance with manufacturer's instructions and NECA National Electrical Installation Standards:
2. Test electronic dimming ballasts for full range dimming capability.
 - a. Check for visually detectable flicker over the full dimming range.
3. Prior to turnover to Owner, replace lamps that were installed and used during construction if more than 15 percent of their rated lamp life has been used.

J. Exterior - General

1. Furnish exterior luminaires that comply with requirements specified in this Section and in the luminaire schedule on the Drawings.
2. Luminaire photometric characteristics shall be based on IESNA approved methods for photometric measurements performed by a recognized photometric laboratory.
3. Luminaire housing shall be primarily metal.
 - a. Metal parts shall be free from burrs and sharp corners and edges.
 - b. Sheet metal components shall be fabricated from corrosion-resistant aluminum, formed and supported to prevent sagging and warping.
 - c. Exposed fasteners shall be stainless steel.
4. Doors and frames shall be smooth operating and free from light leakage under operating conditions.
 - a. Relamping shall be possible without the use of special tools.
 - b. Doors, frames, lenses and diffusers shall be designed to prevent accidental falling during relamping and when secured in the operating position.
 - c. Door shall be removable for cleaning or replacing lens.
5. Luminaires shall have minimum reflecting surface reflectance as follows unless scheduled otherwise:
 - a. White surfaces: 85 percent
 - b. Specular surfaces: 83 percent
 - c. Diffusing specular surfaces: 75 percent
6. Provide lenses, diffusers, covers and globes as scheduled on the Drawings fabricated from materials that are UV stabilized to be resistant to yellowing and other changes due to aging or exposure to heat and ultraviolet radiation.
7. Doors shall have resilient gaskets that are heat-resistant and aging-resistant to seal and cushion lens and refractor.

K. Exterior Poles and Accessories

1. Furnish poles and accessories that comply with requirements specified in this Section and the luminaire schedule on the Drawings.
2. Pole, base, and anchorage shall carry the luminaires, supports, and appurtenances at the indicated height above grade without deflection or whipping.
3. Mountings, fastenings and other appurtenances shall be fabricated from corrosion-resistant materials that are compatible with poles and luminaires and will not cause galvanic action at contact points. Mountings shall correctly position luminaires to provide scheduled light distribution.
4. A reinforced access handhole shall be located in the wall of each metal pole.
5. A welded 1/2 inch grounding lug shall be accessible through the handhole of each metal pole. Grounding connection shall be designed to prevent electrolysis when used with copper ground wire.
6. Metal poles shall have anchor type bases and galvanized steel anchor bolts and leveling nuts.
7. Metal poles shall have a metal base cover that covers the entire base plate and anchorage.
8. Protect painted, anodized, or brushed pole finishes during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape, and shipping small parts in boxes.
9. Aluminum poles shall be fabricated from corrosion resistant aluminum Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys or Alloy 356-T4 for cast alloys.
 - a. Poles shall be square or round, tapered or straight as indicated on the Drawings.
 - b. Aluminum poles over 30 feet tall shall include factory-installed vibration dampers.
 - c. Poles shall be seamless extruded or spun seamless type with minimum 0.188 inch wall thickness.
 - d. Tops of shafts shall be fitted with a round or tapered cover.
 - e. Base shall be anchor bolt mounted, made of cast 356-T6 aluminum alloy in accordance with ASTM B 108/B 108M, Standard Specification for Aluminum-Alloy Permanent Mold Castings and shall be machined to receive the lower end of shaft. Joint between shaft and base shall be welded.
 - f. Hardware, except anchor bolts, shall be either 2024-T4 anodized aluminum alloy or stainless steel.
10. The poles EPA capacity shall meet the wind rating in the geographical area in which its installed. Refer to AASHTO wind map and provide appropriate wind rating with the paired light fixture. Wind rating shall be a minimum of 100MPH with 130MPH gust rating.
11. Anchor bolts shall be steel rod having minimum yield strength of 50,000 psi. The top 12 inch of the anchor bolt shall be galvanized in accordance with ASTM A153/A153M.
12. Manufacturers: Subject to compliance with requirements, provide products as scheduled or specified on the Drawings.
13. Fuses and Fuse holders
 - a. Furnish fuse overcurrent protection for each pole-mounted luminaire to isolate faulted ballasts from the lighting circuit.
 - b. Use 600 volt, Class CC, time-delay, current-limiting fuses.
 - c. Select fuses rated between 200 percent and 300 percent of the luminaire ballast or driver maximum current.
 - d. Manufacturer: Bussman "LP-CC" or approved equal.
14. Furnish in-line fuse holders for installation in pole hand hole or transformer base.

- a. Use non-breakaway type fuse holders unless breakaway poles are indicated on the Drawings.
- b. Use breakaway type fuse holders where breakaway poles are indicated on the Drawings.
- c. Load and line terminal sizes and types shall correspond to line and load conductor sizes and quantities.
- d. Both breakaway and non-breakaway fuse holders shall have insulating boots.
- e. Manufacturers: Ferraz Shawmut "FEC" for phase conductor(s), "FEBN" for neutral conductor, or approved equal.

L. Exterior Installation

1. Install products in accordance with manufacturer's instructions, NECA/IESNA 501, and approved shop drawings.
2. Locations of luminaires and poles shown on the Drawings are diagrammatic. Coordinate luminaire locations with building finishes, building structure, paving and striping, utility piping, security fences, and existing trees. Obtain approval for location changes through LANL Subcontract Technical Representative (STR).
3. Set poles and luminaires plumb, square, level and secure.
4. Install surface mounted luminaires directly to an outlet box which is supported from structure.
5. Install in-grade luminaires flush with surrounding surface. Coordinate pitch or grading of surface with General Contractor to allow drainage away from fixture.
6. Install lamps in luminaires in accordance with manufacturer's instructions.
7. Pre-cast Concrete Foundations:
 - a. Concrete shall be a minimum of 5,000 psi after 28 days.
 - b. Electrical SubContractor shall coordinate conduit requirements, anchor bolt pattern, bolt projection, and approved light pole base including bolt covers with approved light pole prior to release of pre-cast base.
 - c. Base shape shall match pole shape and shall be a minimum of 18 in. or 2 in. larger than pole base bolt covers.
 - d. Comply with details on electrical drawings for dimensions, reveal above grade, and reinforcing.
 - e. Provide Shea concrete products or equal.
8. Pole Erection
 - a. Do not install poles without luminaires.
 - b. Use fabric web slings to raise and set poles.
 - c. Use leveling nuts or shims to make poles plumb. When leveling nuts are used, set the lower nuts not more than 1 inch from the concrete foundation.
 - d. Tighten anchor bolt nuts and other pole hardware to torque recommended by manufacturer.
 - e. After pole is leveled, pack non-shrink grout between anchor base and concrete foundation to provide a full bearing surface. Use a short piece of 1/2 in. diameter pipe to make a drain hole through grout; arrange to drain condensation from interior of pole.

2.09 ELECTRICAL POWER EQUIPMENT

A. Motor Controls - Manual and Solid State:

1. Individually mounted starters shall be NEMA rated solid state type with thermal overload on each reduced voltage start.
2. Motor Starters shall be furnished by Electrical Sub-Contractor unless part of package mechanical equipment such as rooftop units. Refer to equipment schedules on Electrical Plans and provide accordingly.
3. The solid state motor controller shall use silicon controlled rectifiers (SCR's) to control the voltage to the motor windings. Two SCR's shall be used in a back-to-back arrangement in each phase to allow alternating current to pass to the motor. When SCR triggering is delayed, the voltage to the load shall be reduced. This phase-controlled operation provides soft starting with stepless acceleration. Once the motor is running, voltage reduction can improve the motor's operating point at partial load, saving energy and lowering the reactive current. If one or more shorted SCRs are detected, the starter shall not energize. A fault LED will light and if provided with a shunt trip, the main circuit breaker will trip. Provide pump stop option to eliminate water hammer in pumping systems, by giving a controlled decel to the motor voltage. This process shall allow for smooth pressure reduction and quiet check valve operation. The controller shall trip off the line if one or more phases is lost.
4. Starters shall be of size and type required for particular motor horsepower and voltage. Minimum size starter to be size 1 FVNR, unless noted otherwise.
 - a. Starters shall have OL reset button, green push-to-test type pilot light to indicate "ON", and "HAND-OFF-AUTO" switch in cover.
 - b. Starters to have 120 volt control transformers with fused output being provided for those units operating on 277/480 volt system.
 - c. Provide Class 20 fixed heater overloads with auto/manual reset.
 - d. Provide four sets of auxiliary contacts of convertible type N.O. to N.C. for each starter.
 - e. Motor starters shall have NEMA I enclosures. Those in wet locations shall be NEMA 3R.
 - f. Acceptable Manufacturers:
 - 1) Westinghouse/Culter-Hammer
 - 2) Square D/Groupe Schneider
 - 3) Siemens
 - 4) Allen Bradley
 - 5) General Electric
 - 6) Or equal
5. Manual motor starters shall have pilot lights and shall be furnished with thermal overloads on each phase.

B. Motors: Each motor shall have disconnect switch and starter provided under this section.

1. Provide motor terminal boxes for each motor not furnished with same.

C. Disconnect Switches:

1. Disconnect (safety) switches shall conform to industrial standards of NEMA, be UL listed and shall be heavy duty type, quick-make, quick-break type with interlocking cover mechanism and provisions for padlocking switch handle in "OFF" position. Three pole toggle switches are not acceptable as substitute for disconnect switches.
2. Disconnect switches shall be of fused or unfused type as indicated with number of disconnecting poles indicated. The grounded conductor shall not be switched. Switches for use with current limiting fuses shall be rejection type and those used in conjunction with motors shall be horsepower rated. Provide oversize termination lugs if required by conductor size.
3. Enclosures shall be of proper NEMA type for intended location and shall be phosphate coated or equivalent code gauge galvanized sheet steel with ANSI #24 dark gray baked enamel finish.
4. Manufacturers:
 - a. Eaton Cutler Hammer
 - b. Westinghouse
 - c. Square D/Groupe Schneider
 - d. Siemens
 - e. Allen Bradley
 - f. Or equal

D. Fuses:

1. Provide a complete set of fuses for each item of fusible type equipment.
2. Turn over to authorized representative of Owner upon completion a spare set of fuses of each different type and ampere rating installed. These spares shall be bound with twine and tagged.
3. Secondary system fuses, rated at 600 volts or less, shall be UL listed and constructed in conformance with the applicable standards set forth by NEMA and ANSI. All fuses of a particular class shall be of same manufacturer.
4. All fuses in distribution panelboards and switchboards shall be class "L" above 600 amperes and class "RK1" for 600 amperes and below.
5. Main, Feeder, and Branch Circuits:
 - a. Circuits 601 amperes and above shall be protected by (Bussmann type KRP-C LOW-PEAK) current limiting time delay fuses.
 - b. Circuits 0-600 amperes shall be protected by (Bussmann "LOW-PEAK" dual element), time delay current limiting fuses, LPN-RK (250 volts), LPS-RK (600 volts), UL class RK-1.
6. Manufacturers:
 - a. Bussmann, Division of McGraw
 - b. Gould/Shawmut
 - c. GEC-ALSTHOM
 - d. Or equal

2.10 ELECTRICAL SYSTEM CONTROLS AND INSTRUMENTS

- A. Provide a complete power system consisting of branch circuits, motor disconnect switches, pushbutton stations, motor starters, and other devices to connect up and leave in operating condition each piece of electrically operated equipment provided either under this section or other Divisions.

- B. All control wiring, not indicated in the electrical specifications or not shown on electrical drawings, will be provided by Temperature Control Subcontractor.

2.11 GROUNDING SYSTEM

- A. All equipment and systems shall be grounded. Refer especially to NEC Section 250 Requiring Connections to Building Steel, Foundation, Water Service, and Interior Piping. Provide transformer pad grounding in accordance with utility company standards.
- B. Comply with Motorola R56 grounding guidelines.
- C. The grounded conductor shall be supplemented by an equipment grounding system.
- D. The equipment grounding system shall be installed so all conductive items in close proximity to electrical circuits operate continuously at ground potential and provide a low impedance path for ground fault currents.
- E. Grounding conductors shall be so installed as to permit shortest and most direct path to ground.
- F. Maximum measured resistance to ground of 5.0 ohms shall not be exceeded. Ground separately derived systems (dry type transformers) in accordance with Article 250-30 by grounding neutral to transformer ground lug and providing insulated grounding electrode conductor to nearest effectively grounded building steel or, if unavailable, to nearest available effectively grounded metal water pipe.
- G. Equipment grounding conductors and straps shall be sized in compliance with Code Table 250-122.
- H. Grounding conductors shall be insulated with green color. Grounding conductors for use on isolated ground receptacles shall be green with trace color to differentiate between normal ground conductors.
- I. Branch circuits shall consist of phase and grounded conductor installed in common metallic raceway. All receptacle circuits shall have dedicated neutrals. All circuits shall have a separate insulated grounding conductor installed. Any flexible cable system or non-metallic raceway system shall have an insulated grounding conductor. Any cable system for use on isolated ground circuits shall have both an isolated ground conductor as well as an equipment ground conductor, both of which shall be insulated.
- J. Each electrical expansion fitting shall be furnished with a bonding jumper. Provide grounding bushings and ground connections for all raceways terminating below equipment where there is no metal-to-metal continuity.
- K. Continuity between all metallic and nonmetallic raceway systems and equipment shall be maintained.
- L. Outdoor lighting fixtures shall be grounded and bonded in common with building system via a separate grounding conductor.

- M. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- N. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- O. Ground Rods: Drive rods until tops at least 6 inches below finished floor or final grade, unless otherwise indicated. Interconnect ground rods with grounding electrode conductor below grade.
- P. Dry type transformer: Install an insulated grounding conductor from a transformer neutral to the building steel by means of copper wire, as scheduled on the drawings.
- Q. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors in conduit, from a grounding bus of the building's main service equipment to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
 - 4. Refer to Technology Specifications for additional grounding requirements.

2.12 PANELBOARDS

- A. Panelboards shall be dead-front, door in door safety type equipped with single or multi-pole circuit breakers suitable for 120/208 volt or 277/480 volt, 3 phase, 4 wire operation.
- B. Buses shall be copper. Panelboards shall have a circuit directory card mounted in a frame with plastic cover on inside of door. Panelboards shall have a copper ground bus with terminals for each circuit. Panelboards serving isolated ground receptacles shall have a separate ground bus for terminations of the isolated grounds. The isolated ground bus shall be mounted to the panel tub via non-conducting means with a separate grounding conductor run to the normal panel ground bus. Provide oversize lugs for any termination requiring same due to oversize conductors. Provide 200 percent neutral buses on all 120/208 volt panelboards fed from K-rated transformers.
- C. Cabinets shall be minimum of 20 inches wide and be made of code gauge steel. Surface type shall be ordered without knockouts.
- D. Trims shall be made of code gauge steel, surface or flush as indicated. Panelboards shall be keyed alike. Trims shall be provided with full length piano hinge on one side, and secured to tub with

sufficient quantity of latches opposite the hinge side to allow trim to fit flush with tub and when released, allow full access to wiring gutters. Inner door shall allow access to circuit breakers only.

- E. Panelboards shall be of the following types with minimum circuit breaker frame sizes listed below. Refer to schedules for larger circuit breaker frame sizes due to fault current availability.
1. 120/208 volt, three phase, four wire. Symmetrical interrupting capacity 22,000 AIC.
 Style

Westinghouse type PRL-1	BAB Breakers (bolt-on)
Square D type NQOD	QOB Breakers (bolt-on)
Siemens type CDP-7	BQ Breakers (bolt-on)
General Electric Type AQ	HHQB Breakers (bolt-on)
 2. Distribution Panels:
 - a. Where scheduled as circuit breaker type, symmetrical interrupting capacity 65,000 AIC.

Westinghouse type PRL-3	FD Breakers
Square D I-Line type	FA Breakers
Siemens SPP	FXD6 Breakers
General Electrical Spectra	THED Breakers
 3. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 - a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits.
 - b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - c. Electronic trip circuit breakers with field-replaceable rating plug and the following field-adjustable settings:
 - d. Instantaneous trip.
 - e. Long- and short-time pickup levels.
 - f. Long- and short-time time adjustments.
 - g. Ground-fault pickup level, time delay, and I²t response.
 - h. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - i. Standard frame sizes, trip ratings, and number of poles.
 - j. Lugs: Suitable for number, size, trip ratings, and conductor material.
 - k. Application Listing: Type HACR for heating, air conditioning and refrigeration equipment power feeders.
 - l. Shunt Trip: 120-V trip coil energized from separate circuit, where shown on the drawings.
 - m. For circuit breakers 1200Amperes and over provide maintenance mode arc flash reduction feature.
 4. Acceptable Manufacturers:
 - a. Eaton
 - b. Square D/Groupe Schneider
 - c. Siemens

- d. General Electric
- e. Or equal
- F. Branch Devices shall be standard molded case circuit breakers, current limiting circuit breakers, or other devices as scheduled. Branch devices shall be mounted in panelboard type construction. Provide electronic trip breakers with adjustable LSIG settings for all breakers 200 amp and larger.
- G. Panelboards and distribution panels shall be of same manufacturer. Refer to drawings where higher interrupting are required.
- H. Panelboards and distribution panels shall be of same manufacturer as switchboard. Refer to drawings where higher interrupting are required.
- I. Provide arc fault breakers serving all loads in areas listed in NEC 210.12(A) and comply with 210.12(A)(1) through (6).
- J. All power panels fed from K-13 transformers shall have surge protection. Coordination and Arc flash study shall be submitted with shop drawing submittal. All circuit breaker selection shall meet study recommendations and shall be provided as recommended by study.
- K. Electrical Sub-contractor shall provide infrared scanning of all panelboards after three months past substantial completion. Provide report indicating status of all terminations at respective panelboards per phase.

2.13 ELECTRIC SERVICE

- A. Coordinate and cooperate with National Grid hereinafter called utility company, with respect to providing service and metering.
- B. Provide all primary system raceways, elbows, pull wires and all pad grounding. Utility company will provide pad mounted transformer and primary conductors including making up of all terminations and connections.
- C. Provide secondary service complete including all conductors, raceways, and connectors at transformer. Provide oversize lugs if required due to conductor sizing. Attachment of secondary conductors to the transformer terminals will be done by the E.C.
- D. General Trades Contractor will do all excavation and back filling in accordance with utility company standards and will provide the concrete pad for transformer.
- E. All work to be done in accordance with utility company standards.
- F. Metering: All usage will be on secondary meters. One meter will be installed on the secondary of each transformer. Utility Company will furnish current transformers and potential transformers to be installed in switchboard. Provide meter socket per utility company standards. Meter will be by the Utility Co.

2.14 MANUAL TRANSFER SWITCH

- A. Scope:

1. Contractor shall furnish, deliver, install and test the manual transfer switches as specified herein and in accordance with the drawings.
- B. Quality Assurance:
1. Manual transfer switch shall be UL listed and labeled under the UL 1008 standard.
 2. Manual transfer switch manufacturer shall provide a complete factory assembled, wired and tested manual transfer switch.
 3. Manual transfer switch shall be factory Hi-pot tested for a period of not less than 60 seconds.
 4. Manual transfer switch installation shall meet all applicable NEC standards.
- C. Submittals:
1. Contractor shall submit manufacturer's drawings and data of manual transfer switches for Engineer's approval prior to start of fabrication. Drawings and data shall include, as a minimum, dimensioned general arrangement drawings and wiring diagrams, UL listing information including UL control or file number, component data, mounting provisions, conduit entry locations and installation instructions.
 2. Upon installation of manual transfer switches Contractor shall submit manufacturer's Operating & Maintenance Manual which shall include as a minimum:
 - a. Certified as-built General Arrangement drawings and Wiring Diagram.
 - b. Materials / Component List including part numbers.
 - c. Maintenance and service requirements.
 - d. Certificate of Compliance and hi-pot test data.
- D. Warranty:
1. Manual transfer switches shall be covered by manufacturer's warranty for a minimum period of (1) one year after shipment from manufacturer.
- E. General:
1. All equipment shall be new.
 2. Manual transfer switch manufacturer must have produced and sold manual transfer switches as a standard product for a minimum of (3) years.
 3. Manual transfer switches shall be molded case circuit breaker type; knife switch or fused switches are not acceptable.
 4. Contractor shall be responsible for the equipment until it has been installed and is finally inspected, tested and accepted in accordance with the requirements of this Specification.
 5. Manual transfer switches shall be as follows:
 - a. Public Safety Building:
 - 1) StormSwitch, Model "SSDX-100A-H-100A-H-480-3-1-1-S-C" as manufactured by ESL Power Systems, Inc. or equal as approved by the Engineer.
 - b. Fire Station:
 - 1) StormSwitch, Model "SSDX-100A-H-100A-H-480-3-1-1-S-C" as manufactured by ESL Power Systems, Inc. or equal as approved by the Engineer.
 - c. DPW

- 1) StormSwitch, Model “SSDX-100A-H-100A-H-480-3-1-1-S-C” as manufactured by ESL Power Systems, Inc. or equal as approved by the Engineer.
6. Refer to drawings for voltages, quantities and configurations.

F. Manual Transfer Switches:

1. Manual transfer switch shall consist of (2) two mechanically-interlocked molded case circuit breakers, cam-style male connectors, power distribution block and grounding terminals, all housed within a padlockable enclosure.
2. Manual transfer switch enclosure shall be Type 3R, constructed of continuous seam-welded, powder coated galvanized steel. The main access shall be through an interlocked, hinged door that extends the full height of the enclosure. Access for portable generator cables with female cam-style plugs shall be via cable entry openings in the bottom of enclosure. A hinged flap door shall be provided to cover the cable openings when cables are not connected; the hinged flap door shall allow cable entry only after the main access door has been opened. Enclosure shall be powder coated after fabrication; color shall be light gray RAL 7038.
3. Cam-style male connectors (inlets) shall be UL Listed single-pole separable type and rated 800 amps at 600VAC. Cam-style male connectors shall be color coded. Cam-style male connectors shall be provided for each phase and for ground, and shall also be provided for neutral if required. Each of the phase cam-style male connectors within the enclosure shall be factory-wired to a molded case circuit breaker. The ground cam-style male connectors shall be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. The neutral cam-style male connectors, if required, shall be factory wired to a power distribution block. None of the cam-style male connectors shall be accessible unless both molded case circuit breakers are in the “OFF” position and the main access door is open.
4. A power distribution block shall be provided for load-side field wiring. The power distribution block shall be factory wired to the molded case circuit breakers.
5. Molded case circuit breakers shall be UL Listed and the short circuit interrupt rating shall be a minimum of 35kAIC at 480VAC. Trip rating of the molded case circuit breakers shall be as shown on the drawings. One molded case circuit breaker shall be fed from utility power; the other molded case circuit breaker shall be fed from the cam-style male connectors to supply power from a portable generator. Both molded case circuit breakers shall include UL Listed door-mounted operating mechanisms, preventing the opening of the main access door unless both breakers are in the “OFF” position. Both molded case circuit breakers shall be mounted behind a deadfront panel. The load-side of the molded case circuit breakers shall not be energizable unless the main access door is closed and one of the molded case circuit breakers is in the “ON” position. The (2) molded case circuit breakers shall be safety interlocked by mechanical means to ensure that only one breaker can be closed at any given time.
6. Manual transfer switch shall be suitable for use as service equipment in the USA.
7. Provide with auxiliary contacts for connection to BMS/Fire alarm system to indicate the permanent generator has been disconnected from the emergency system.

G. Installation:

1. Prior to installation of manual transfer switches, Contractor shall examine the areas and conditions under which the manual transfer switch is to be installed and notify the Engineer in writing if unsatisfactory conditions exist.
2. Manual transfer switch shall be installed as shown on the drawings and per the manufacturer's written instructions. In addition, the installation shall meet the requirements of local codes, the National Electrical Code and National Electrical Contractors Association's "Standard of Installation".
3. Conduit entry into the manual transfer switch shall be by Contractor; Contractor shall furnish and install listed watertight conduit hubs, as manufactured by MYERS or T&B, for each conduit entry on the manual transfer switch. The incoming hub size shall match the conduit size for feeders and ground as shown on the drawings. The outgoing hub size shall match the conduit size for loads and ground as shown on the drawings. Hubs shall be properly installed and tightened to maintain Type 3R integrity of the manual transfer switch enclosure.
4. Contractor shall terminate feeder conductors, load conductors and ground per the manufacturer's instructions. Use copper wire only for all conductors and grounds. All field wiring terminations shall be torqued as required per the instructions on the manual transfer switch's power distribution block, circuit breaker & ground lug.

H. Field Testing:

1. Prior to energizing manual transfer switch, the Contractor shall perform the following checks and tests as a minimum:
 - a. Verify mounting and connections are complete and secure.
 - b. Verify internal components and wiring are secure.
 - c. Perform continuity check of all circuits.
 - d. Perform 1,000 VDC megger test on feeder, load and ground cables.
 - e. Verify deadfront is secure.
 - f. With the manual transfer switch deadfront in place and the main access door closed and properly latched, actuate both Operator Mechanisms; verify only
(1) breaker at a time can be turned to the "ON" position.
 - g. Confirm operation of the manual transfer switch ground receptacle by attaching a plug to the manual transfer switch ground receptacle and then verify that the plug is grounded to the facility ground.
 - h. Once utility power has been applied, confirm operation of manual transfer switch by following directions on main access door.

2.15 GENERATOR TAP BOX

A. Scope:

1. Contractor shall furnish, deliver, install and test the generator tap boxes as specified herein and in accordance with the drawings.

B. Quality Assurance:

1. Generator tap boxes shall be UL listed and labeled under the UL 1008 standard with a minimum 22KA withstand rating. Withstand rating shall match the switchgear for the building.

2. Generator tap box manufacturer shall provide a complete factory assembled and tested generator tap box.
3. Generator tap box installation shall meet all applicable NEC standards.

C. Submittals:

1. Contractor shall submit manufacturer's drawings and data of generator tap boxes for Engineer's approval prior to start of fabrication. Drawings and data shall include, as a minimum, dimensioned general arrangement drawings, UL listing information including UL control or file number, component data, mounting provisions, conduit entry locations and installation instructions.

D. Warranty:

1. Generator tap boxes shall be covered by manufacturer's warranty for a minimum period of (1) one year after shipment from manufacturer.

E. General:

1. All equipment shall be new.
2. Generator tap box manufacturer must have produced and sold generator tap boxes as a standard product for a minimum of (2) years.
3. Contractor shall be responsible for the equipment until it has been installed and is finally inspected, tested and accepted in accordance with the requirements of this Specification.
4. Generator tap boxes shall be TempTap Inlet Boxes as manufactured by ESL Power Systems, Inc. or equal as approved by the Engineer.

F. Generator Tap Boxes:

1. Generator tap box shall consist of cam-style male connectors and grounding terminals, all housed within a padlockable enclosure.
2. Generator tap box enclosure shall be Type 3R, constructed of continuous seam-welded, powder coated galvanized steel. The main access shall be through a hinged door that extends the full height of the enclosure. Access for portable generator cables with female cam-style plugs shall be via cable entry openings in the bottom of the enclosure. A hinged flap door shall be provided to cover the cable openings when cables are not connected; the hinged flap door shall allow cable entry only after the main access door has been opened. Enclosure shall be powder coated after fabrication; color shall be light gray RAL 7038.
3. Cam-style male connectors (inlets) shall be UL Listed single-pole separable type and rated 400 amps at 600VAC. Cam-style male connectors shall be color coded. Cam-style male connectors shall be provided for each phase and for ground, and shall also be provided for neutral if required. The ground cam-style male connectors shall be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. None of the cam-style male connectors shall be accessible unless the main access door is open.

G. Installation:

1. Prior to installation of generator tap boxes, Contractor shall examine the areas and conditions under which the generator tap box is to be installed and notify the Engineer in writing if unsatisfactory conditions exist.

2. Generator tap box shall be installed as shown on the drawings and per the manufacturer's written instructions. In addition, the installation shall meet the requirements of local codes, the National Electrical Code and National Electrical Contractors Association's "Standard of Installation".
3. Conduit entry into the manual transfer switch shall be by Contractor; Contractor shall furnish and install listed watertight conduit hubs, as manufactured by MYERS or T&B, for each conduit entry on the generator tap box. The hub size shall match the conduit size for conductors and ground as shown on the drawings. Hubs shall be properly installed and tightened to maintain Type 3R integrity of the generator tap box.
4. Contractor shall terminate conductors and ground per the manufacturer's instructions. Use copper wire only for all conductors and grounds. All field wiring terminations in the generator tap box shall be torqued as required per the instructions on the generator tap box.

H. Field Testing:

1. Prior to energizing generator tap box, the Contractor shall perform the following checks and tests as a minimum:
2. Verify mounting and connections are complete and secure.
3. Verify internal components and wiring are secure.
4. Perform continuity check of all circuits.
5. Perform 1,000 VDC megger test on phase and ground cables.
6. Verify deadfront is secure.
7. Confirm operation of the generator tap box ground receptacle by attaching a plug to the generator tap box ground receptacle and then verify that the plug is grounded to the facility ground.

2.16 STANDBY ELECTRICAL SYSTEM

A. Summary

1. Work Included: Packaged diesel fired engine driven electric plant including engine generator set, cooling system, combustion air intake and engine exhaust systems, starting system, and the following additional features:
 - a. Weatherproof and soundproof housing.
 - b. Automatic load transfer control to provide automatic starting and stopping of the plant and switching of the load within 10 seconds.
 - c. Automatic transfer switches
 - d. Remote annunciator panel.
 - e. 10' exhaust stack for generators rated 300KW and above.
2. Provide control and alarm circuits wiring as shown on the manufacturer's diagrams and required for a complete installation.
3. Provide labor, materials, tools, equipment, transportation, insurance, temporary protection, supervision and incidental items which are usually provided with this equipment, or which are essential for proper installation and operation, even though not these may not be specifically mentioned or indicated on the drawings.

B. REFERENCED STANDARDS

1. National Electrical Manufacturers' Association: NEMA MG1 - Motors and Generators.

2. UL142 - Steel aboveground tanks for flammable and combustible liquids.
3. UL2200 – Stationary engine generator set assemblies.
4. Massachusetts DEP regulations and Federal EPA certification.

C. SUBMITTALS

1. Product Data: Submit product data showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine, generator, control panel, automatic transfer switches, battery, battery rack, battery charger, exhaust silencer, vibration isolators, radiator, enclosure and remote annunciator. Submit manufacturer's installation instructions.
 - a. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - b. Include thermal damage curve for generator.
 - c. Include time-current characteristic curves for generator protective device.
 - d. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
 - e. Include airflow requirements for cooling and combustion air in cubic feet per minute at 0.8 power factor, with air-supply temperature of 104 deg F. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
 - f. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactance's, and short-circuit current capability.
2. Shop Drawings: Prepare and submit complete shop drawings of the emergency generator set and enclosure, including plan and elevation views with overall and interconnection point dimensions, fuel consumption rate curves at various loads, and electrical diagrams, including schematic and interconnection diagrams.
 - a. Include plans and elevations for engine generator and other components specified. Indicate access requirements.
 - b. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - c. Identify fluid drain ports and clearance requirements for proper fluid drain.
 - d. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - e. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
 - f. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams indicating terminal markings for engine generators and functional relationship between all electrical components.
 - g. Certified summary of prototype-unit test report.
 - h. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 - i. Report of factory test on units to be shipped for this Project, indicating evidence of compliance with specified requirements.
 - j. Report of sound generation.
 - k. Report of exhaust emissions indicating compliance with applicable regulations.
 - l. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

3. Test Reports: Submit certified copies of reports of factory testing required by this section.
4. Closeout Submittals: For inclusion the Operating and Maintenance Manual specified in Division 1, provide the required number of copies of operating and maintenance information, parts manuals, and schematic and wiring diagrams.
5. Provide an excel spreadsheet all maintenance requirements and schedule of service/maintenance to the owner to be input into Dude solutions maintenance program.

D. QUALITY ASSURANCE

1. Installer: Company specializing in performing the work of this section with minimum three years experience.
2. NEMA Standards: Furnish and install motors to conform to NEMA MG1.
3. Code: Furnish and install emergency generator to comply with provisions of the referenced Electrical Code.

E. DELIVERY, STORAGE, AND HANDLING

1. Deliver, store, and protect products under provisions of Section 260000.
2. Accept packaged engine generator set and accessories on site in crates and verify damage.
3. Protect equipment from dirt and moisture by securely wrapping in heavy plastic.

F. WARRANTY

1. Provide written warranty, signed by the manufacturer and installer of the emergency generator equipment, agreeing to repair or replace at no cost to the Owner, equipment which is defective either in material or workmanship.
 - a. Warranty Period: 5 years from the date of Substantial Completion of construction.
2. On-going system service and support shall be available from multiple factory certified vendors. Include generator package the recommended service agreement. Provide recommended service agreement pricing at the time of bid for one year post completion.

G. MAINTENANCE MATERIALS

1. Furnish one set of tools required for preventative maintenance of the engine generator system. Package tools in adequately sized metal tool box.
2. Provide two additional sets of each fuel oil, and air filter elements required for the engine generator system.

H. Provide one 400 KW, 500KVA @ .8PF, 277/480V 3 Phase, 4 Wire standby power rated diesel-fueled generator sets, mounted in perfect alignment on an all welded, fabricated steel sub-base which shall allow for attachment of all necessary engine and generator accessories.

I. Manufacturers:

1. Kohler
2. Generac
3. Caterpillar
4. Onan/Cummings
5. Or equal

J. Engine

1. Water cooled with unit-mounted radiator. Provide starter and all field wiring required by manufacturer
2. Dry-type replaceable element air cleaners.
3. Full flow lube oil filters and bypass oil filter.
4. Twelve (12) volt starting motor, 12 volt, 3 ampere battery charging alternator.
5. Engine instrument panel to include ammeter, lube oil pressure gauge, lube oil temperature gauge, water temperature gauge, and hour meter.
6. Engine-mounted safety control to provide alarm signals for engine shutdown in event of low oil pressure, high coolant temperature, overspeed, over crank, and pre-alarms for high water temperature and low oil pressure.
7. Jacket water heater, 2000 watt, 120 or 208 volt, single phase or as recommended by generator manufacturer.

K. Generator: One 400KW, 500KVA @ .8PF, 277/480, 3 phase, 4 wire, 60 Hz, diesel fired 1800 RPM revolving field type main generator with brushless exciter and permanent magnet.

1. Voltage regulation +/- 1 percent from no load to full load.

L. Cooling System: Unit mounted radiator with flange attached.

M. Starting System: 12 volt heavy duty lead acid storage battery, connected for 12 volt DC output.

1. Battery rack, cables, and connectors shall be provided.
2. Provide 10 amp battery charger fed from a 120 volt, single phase, 60 Hz service. Battery charger to include high and low battery voltage alarm relays for derangement panel. Battery charger shall meet NFPA 110 Standards.
3. Exhaust System: Furnish one Maxim M-51 3 in. critical silencer, 3 in. side inlet, and one 3 in. end outlet complete with two (2) 3 in. companion flanges. Furnish one 3 in. x 18 in. flexible stainless steel exhaust connector, flanged on one end, threaded nipple on opposite end. Generator shall meet all applicable emissions regulations.

N. Vibration Isolators: Set of four (4) Korfund rubber type vibration isolators for installation between steel base and concrete foundation.

O. Exhaust System: Furnish one Maxim M-51 3" critical silencer, 3" side inlet, and one 3" end outlet complete with two (2) 3" companion flanges. Generator shall be Tier 3 compliant and meet all applicable emission standards. Furnish one 3" x 18" flexible stainless steel exhaust connector, flanged on one end, threaded nipple on opposite end. Furnish a stainless steel 10' stack exhaust extension supported from the generator housing with rain cap and all necessary components for a complete installation in accordance with Commonwealth of Massachusetts and DEP regulations. Stack shall be powder coated with black heat resistant paint.

P. Generator Control Panel:

1. To completely control operation of engine generator set. Panel to have automatic start control, AC volt meter, AC ammeter, pointer type frequency meter, volt meter, ammeter and selector switch. Alarm signals to indicate pre-low oil pressure, pre-high coolant temperature, and alarm signals to shut down engine in event of a low oil pressure, high coolant temperature, engine overspeed, or overcrank. Lights on face of panel to indicate

- failure. Provide dry contacts for remote disarrangement signal & louvers. Locate remote annunciator in administration area.
2. Terminal strip shall be included with alarms and prewarning devices prewired for remote annunciator specified herein. Provide wiring between generator and remote annunciator panel. Generator control switch shall be mounted on control panel face. A flashing light for selector switch "OFF" shall be included.
 3. Provide molded case line circuit breakers mounted on generator in oversized terminal box. Provide oversized frame and LSIG type breaker in Life Safety branch, to ensure full selectivity coordination on the life safety system.
 4. Generator Overcurrent Protection: The generator set shall be provided with a UL Listed/CSA Certified protective device that is coordinated with the alternator provided to prevent damage to the generator set on any possible overload or overcurrent condition external to the machine. The protective device shall be listed as a utility grade protective device under UL category NRGU. The control system shall be subject to UL follow-up service at the manufacturing location to verify that the protective system is fully operational as manufactured. Protector shall perform the following functions:
 - a. Initiates a generator kW overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
 - b. Under single phase or multiple phase fault conditions, or on overload conditions, indicates an alarm conditions when the current flow is in excess of 110% of rated current for more than 10 seconds.
 - c. Under single phase or multiple phase fault conditions, operates to switch off alternator excitation at the appropriate time to prevent damage to the alternator.
 - d. The operator panel shall indicate the nature of the fault condition as either a short circuit or an overload.
 - e. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot greater than 120% of nominal voltage.

Q. Load Bank

1. Automatically controlled multiple stage resistor load bank in NEMA I enclosure intended for outdoor mounting to the generator in series with the engine radiator.
2. Characteristics: Unit shall be made up of (4) continuously rated 25% Steps, 3 phase resistance stages with voltage rating to match generator output, designed and connected so as to provide a load of up to 50% of generator rating.
3. Construction: The load bank shall be completely self-contained, incorporating all of the following, integrally mounted in a single enclosure, except as otherwise noted:
 - a. Four (4) independent resistance stages made up of chromium alloy wire, each so connected as to provide a 50 % at rated voltage. Resistors shall operate at a temperature not to exceed 1,100 deg F (600 deg C).
 - b. A 3-pole magnetic contactor and 3 current limiting fuses for each stage.
 - c. Fused control transformer with 120 volt output.
 - d. Integral manual override control to permit staged manual on-off control as desired.
 - e. Load bank shall be located in-line with, and downstream of the generator radiator.
 - f. Complete set of factory installed power and control wiring. Power wiring shall be rated for 150 deg C operation.
4. Construction: The load bank shall be completely self-contained, incorporating all of the following, integrally mounted in a single enclosure except as otherwise noted:

- a. Load steps: Not less than four (4) independent resistance stages, made up of
 - b. chrome alloy wire, connected so as to provide load steps up to the total rating of the load bank. No stage shall exceed 50 KW.
 - c. Each resistance stage shall be independently protected by means of factory installed current limiting fuses and shall be provided with a magnetic contactor. Fuses and magnetic contactor shall be factory wired so as to provide a self-protected, individually controllable unit for each stage.
 - d. Main terminals arranged to accommodate a single power connection, sized for the full load rating of the load bank, complete with power circuit extensions to the protective devices for each branch circuit (i.e., stage).
 - e. Automatic protection against regenerative power from elevators. Include reverse
 - f. Both control panels include step-by-step manual control as well as status lights.
- 5. Malfunction detection system shall incorporate sensors, alarms and wiring for intake and exhaust air over temperature and loss of cooling airflow; so arranged as to shut down load bank to avoid overheating.
 - 6. Complete set of factory installed power and control wiring. Cooling fan and control power shall be derived from a protected tap on the load side of the nearest transfer switch.

R. Automatic Transfer Switches:

- 1. Provide two automatic transfer switches as shown on drawings for operation on one 277/480 and one 120/208 volts, 3 phase, 4 wire operation. Units to be housed in a NEMA 1 enclosure and shall be 3 pole with by-pass isolation as indicated on drawings.
- 2. The transfer switches shall be rated for 65,000 ARMS when rated over 400 amperes. Transfer switches shall be rated 42,000 ARMS when rated 400 amperes or less and fed from a current limiting breaker.
- 3. Entire switch shall be listed under UL 1008.
- 4. Manufacturers:
 - a. Russ Electric
 - b. ASCO
 - c. Kohler
 - d. Onan/Cummins
 - e. Or equal
- 5. Unit shall be provided with standard accessories as follows.
 - a. Voltage and Frequency Sensing:
 - 1) Close differential voltage sensing on all phases of normal pickup adjustable 85-100 percent. Dropout 75-98 percent
 - 2) Voltage sensing of emergency source. Adjustable pickup 85-100 percent.
 - 3) Frequency sensing of emergency source. Adjustable pickup 90-100 percent.
 - b. Time Delays:
 - 1) Time delay to override momentary normal source outages. Adjustable 0.5 to 6 seconds.
 - 2) Retransfer to normal with 5 minute cooldown timer.
 - c. Engine Control:
 - 1) Contact to close when normal source fails.
 - 2) Contact to open when normal source fails.
 - 3) Test switch to simulate normal source failure.
 - d. Indicators: Pilot lights to indicate switch in normal position or emergency position.

- e. Auxiliary Contacts: Two (2) to close on normal. Two (2) to close on emergency.
 - f. Bypass/Isolation Switches:
 - 1) Source Limitations: Same manufacturer as transfer switch in which installed.
 - 2) Comply with requirements for Level 1 equipment according to NFPA 110.
 - 3) Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
 - a) Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
 - b) Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
 - c) Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
 - d) Transition:
 - e) Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.
 - f) Provide open-transition operation when transferring between power sources.
 - g) Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
 - h) Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
 - i) Automatic and Nonautomatic Control: Automatic transfer-switch controller shall also control the bypass/isolation switch.
 - j) Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
 - k) Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
 - 4) Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.
6. Required Accessories:
- a. Plant exerciser.
 - b. In-phase monitor (Motor Load Transfer). (ATS-OS)
 - c. Manual transfer to normal source.
 - d. Engine Start control and Monitoring
 - 1) The Engine Start Control and Monitoring Modules shall be ASCO 5101 Engine Start Modules or equal. The solution must cover and provide complete compliance to the 2017 NEC 700.10 code.

- 2) The ATS shall provide continuous monitoring of the entire remote start circuit. Visual and audible annunciation of generator malfunction shall be initiated if the integrity of the start circuit is compromised.
- 3) There shall be minimum time delay (less than 5 seconds) in annunciation of any compromised condition such as an open or short circuit. A system which annunciates compromised conditions only after a generator start signal is initiated via a redundant path does not meet the intent of this specification.
- 4) The detection of a compromised start circuit shall initiate and latch the generator start circuit.
- 5) Each Generator Engine Start Module shall be din-rail mounted and accept up to (8) ATS Engine Start. Each channel must have its own dedicated tri-colored status LED.
- 6) Each Engine Start channel must have its own dedicated switch with ability to enable or disable monitoring function.
- 7) Engine-start circuit shall be a single pair of typical hardwire used in legacy applications. Additional wiring and components beyond specified herein does not meet the intent of this specification.
- 8) Coordinate placement of required components within the generator controls with the specified manufacturers.

S. Provide remote emergency power off button on the generator external to the enclosure.

T. Remote Annunciator Panel: A flush mounted panel shall include a visual signal that battery charger is functioning properly and both audible and visual signals. Annunciator shall meet NFPA 110 Standards.

1. Audible signal shall have a silencing switch. A lamp test button shall be provided.

U. Factory Testing: A certified factory test to be conducted at 1.0 power factor. Test for four (4) hours, one hour each at 25 percent, 50 percent, 75 percent and 100 percent load. Take standard readings and submit test reports for approval prior to shipment. Also, perform field test with load bank at same ratings for 2 hours, in addition to the 2 hour building load test specified below. All fuel for field test shall be provided by Electrical Contractor.

V. Provide load bank test in the field by a factory certified representative for two hours at 25 percent, 50 percent, 75 percent and 100 percent load for 30 minutes at each stage and provide testing documentation. Also, provide a two hour building load test transferring the ATS switches to generator power. Provide an NFPA 110 test report for Engineer approval.

W. Miscellaneous: Necessary lube oil and anti-freeze.

X. REMOTE ALARM ANNUNCIATOR PANEL

1. Provide a generator set remote alarm annunciator panel for installation at the location shown on the drawings.
2. Enclose the panel in NEMA 1 enclosure suitable for flush wall mounting and provide audible (A) and/or visual (V) signals for the following:

Condition	Signal

1.	Generator set operating	V
2.	Failed to start	A/V
3.	Pre-low lube oil pressure	A/V
4.	Pre-high water temperature	A/V
5.	Low water temperature	A/V
6.	Engine overspeed	A/V
7.	Low battery voltage	V
8.	High battery voltage	V
9.	Low fuel supply	A/V
10.	Fuel leak detection	A/V

3. In the panel face, provide a separate lamp for each of the signals listed above, a lamp test pushbutton switch, and an audible alarm signal device with silence switch having ring back feature.
4. Provide a communication port to interface with the building management system for transmitting the generator set status and alarms data including alarm on a generator set failure to start automatic weekly exercise.
5. Supports industry-standard Modbus_RTU protocol.
6. Uses either an RS-232 or RS-485 Network port.
7. Communicates at baud rates up to 19200.
8. Allows selection of an access code for remote programming.
9. Remotely monitors system operation including run times, shutdowns, warnings, and input/output activity.
10. Allows selection of either metric (SI) or English (IP) units.
11. Provides more than 100 different Modbus_message codes for system monitoring, including System Ready and Generator Running.
12. Provides remote programming of most system parameters including time delays, trip points, voltage, frequency, and current.
13. Allows remote engine start/stop and controller reset.

Y. Equipment Testing and Instruction Manual and Drawings:

1. Operating instructions and maintenance manuals shall contain the following information:
 - a. Operating Instructions
 - b. Replacement Parts
 - c. Wiring Diagram
 - d. Maintenance
2. The entire emergency system shall be field test operated for two (2) hours. A normal power failure shall be simulated. The engine generator unit shall automatically start, come up to speed, and assume full emergency load. Entire building shall be in operation during test.
3. Custodians of the equipment shall be present during test. At that time they shall be instructed in operation and maintenance.
4. Upon completion of tests, written reports containing results shall be submitted. Test reports shall contain readings taken at 30 minute intervals along with all other pertinent test information.
 - a. Ambient Temperature
 - b. Oil Pressure
 - c. Battery Charge Rate

- d. AC Volts
- e. AC Amperes All Phases
- f. Frequency
- g. Kilowatts
- h. Power Factor

Z. Coordination of Trades:

1. The following equipment shall be furnished by Electrical Contractor but shall be installed under other sections.
 - a. Anchor bolts to be installed by General Trades Contractor based on approved shop drawings.

AA. Generator Outdoor Housing

1. The engine generating set shall be factory installed in a weatherproof outdoor housing. The housing shall provide year round generating set protection against adverse weather and environmental conditions. The enclosure shall be sound attenuated and meet Federal Specifications.
2. The weatherproof shelter shall be constructed or welded and bolted of reinforced aluminum, 14 gauge walls and 14 gauge floor plate. All metal parts shall be prime coated and finished painted.
3. The shelter assembly shall have shuttered air openings on front and sides with mesh screens covering side shutters. The air shutters shall be opened by four 22 volt AC motors when the generating set operates. Motors shall be spring loaded to close shutters when set stops.
4. Hinged double doors on each side and one door in rear of the shelter shall allow easy access to engine generator and controls. All door handles shall be key lock design.
5. Vibration isolators of the open coil spring type, selected for 3 inch (76mm) static deflection, shall be furnished and installed. The number of isolators shall be as recommended by the generator set manufacturer, and complete details shall be included in the Submittals. Anchor bolts, nuts and sleeves shall be supplied with recommended Foundation Plan.
6. Provide an integral base mounted tank, double wall containment with alarms and capacity to run generator for 72 hours at 100% load. Include conduit entry provisions for tank. Tank shall be supplied in accordance with the state Fuel Storage Codes for above ground diesel fuel tanks. Provide a full tank of diesel. E.C. shall fill diesel tank after all testing is complete and provide all required diesel fuel for testing. Provide tank level gauge at annunciator.
7. The weatherproof housing shall allow installation of the silencer outside or inside the enclosure. Provide critical type silencer.
8. Provide sound deadening materials, baffles, hoods, etc. to reduce noise levels to 75DBA at 7 meters in any direction.

2.17 FIRE ALARM AND DETECTION SYSTEM

A. Description:

1. This section of the specification includes the furnishing, installation, connection and testing of the microprocessor controlled, intelligent reporting fire alarm network equipment rearm initiating devices, alarm notification appliances, Network Fire Alarm Control Panel

- (FACP), auxiliary control devices, annunciators, and wiring as shown on the drawings and specified herein.
2. The fire alarm system shall comply with requirements of latest NFPA Standard 72 for Protected Premises Signaling Systems except as modified and supplemented by this specification. The system shall be electrically supervised and monitor the integrity of all conductors.
3. The fire alarm manufacturer shall be of the highest caliber and insist on the highest quality. The system shall be manufactured by an ISO 9001 certified company and meet the requirements of BS EN9001: ANSI/ASQC Q9001-1994.
4. The FACP and peripheral devices shall be manufactured 100 percent by a single U.S. manufacturer (or division thereof).
5. The system and its components shall be Underwriters Laboratories, Inc. listed under the appropriate UL testing standard as listed herein for fire alarm applications and shall be in compliance with the UL listing.
6. The installing company shall employ NICET (minimum Level II Fire Alarm Technology) technicians on site to guide the final check-out and to ensure the systems integrity.
7. Any system that is proprietary and does not allow multiple fire alarm service vendors to work on/service, the system will be prohibited on this project. All programming software shall be provided with the system.

B. Scope:

1. A new network intelligent reporting, microprocessor controlled fire detection and alarm system shall be installed in accordance with the specifications and drawings.
2. Basic Performance:
 - a. Alarm, trouble and supervisory signals from all intelligent reporting devices shall be encoded onto NFPA Style 7 (Class A) Signaling Line Circuits (SLC).
 - b. Initiation Device Circuits (IDC) shall be wired Class A (NFPA Style D).
 - c. Notification Appliance Circuits (NAC) shall be wired Class A (NFPA Style Z).
 - d. Digitized electronic signals shall employ check digits or multiple polling.
 - e. Power for initiating devices and notification appliances must be from the main fire alarm control panel.
 - f. A single ground or open on any system signaling line circuit, initiating device circuit, or notification appliance circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
 - g. Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
3. System Functional Operation:

When a fire alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:

 - a. The FACP alarm LED on the FACP shall flash.
 - b. A local piezo-electric signal in the FACP control panel shall sound.
 - c. The 80-character LCD display on the local FACP node and on the intelligent network display shall indicate all information associated with the fire alarm condition, including the type of alarm point, and its location within the protected premises. This information shall also be displayed on the network reporting terminal.
 - d. Printing and history storage equipment shall log the information associated with the fire alarm control panel condition, along with the time and date of occurrence.

- e. All system output programs assigned via control-by-event interlock programming to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated on either local outputs or points located on other network nodes.
4. Software Modifications:
 - a. Provide the services of a factory trained and authorized technician to perform all system software modifications, upgrades or changes. Response time of the technician to the site shall not exceed 4 hours.
 - b. Provide all hardware, software, programming tools and documentation necessary to modify the fire alarm network on site. Modification includes addition and deletion of devices, circuits, zones and changes to system operation and custom label changes for devices or zones. The system structure and software shall place no limit on the type or extent of software modifications on-site. Modification of software shall not require power-down of the system or loss of system fire protection while modifications are being made.
5. Certifications:
 - a. Together with the shop drawing submittal, submit a certification from the major equipment manufacturer indicating that the proposed supervisor of installation and the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer and trained on network applications. Include names and addresses in the certification.
 - b. Power supplies, relays, water flow switches and all accessories of the fire alarm system.
 - c. Each circuit in the fire alarm network shall be tested semiannually.
 - d. Each smoke detector shall be tested in accordance with the requirements of NFPA 72, Chapter 7.
- C. Applicable Publications:

The publications listed below form a part of this specification. The publications are referenced in text by the basic designation only.

 1. National Fire Protection Association (NFPA) - USA:

No. 72	National Fire Alarm Code
No. 70	National Electric Code
No. 101	Life Safety Code
 2. Underwriters Laboratories Inc. (UL) - USA:

No. 50	Cabinets and Boxes
No. 268	Smoke Detectors for Fire Protective Signaling Systems
No. 864	Control Units for Fire Protective Signaling Systems
No. 268A	Smoke Detectors for Duct Applications
No. 521	Heat Detectors for Fire Protective Signaling Systems
No. 228	Door Closers-Holders for Fire Protective Signaling Systems
No. 464	Audible Signaling Appliances
No. 38	Manually Actuated Signaling Boxes
No. 346	Waterflow Indicators for Fire Protective Signaling Systems
No. 1481	Power supplies for Fire Protective Signaling Systems

No. 1076 Control Units for Burglar Alarm Proprietary Protective Signaling Systems
No. 1971 Visual Notification Appliances

3. Local and State Building Codes.
4. All requirements of the Authority Having Jurisdiction (AHJ).

D. Approvals:

1. The system must have proper listing and/or approval from the following nationally recognized agencies:
UL Underwriters Laboratories Inc.
FM Factory Mutual
MEA Material Equipment Acceptance (NYC)
CSFM California State Fire Marshal
2. The fire alarm control panel shall meet the modular labeling requirements of Underwriters Laboratories, Inc. Each subassembly, including all printed circuits, shall include the appropriate UL modular label. Systems which do not include modular labels which may require return to the manufacturer for system upgrades, and are not acceptable.

E. Equipment and Material, General:

1. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protected premises protective signaling (fire alarm) system. The authorized representative of the manufacturer of the major equipment, such as control panels, shall be responsible for the satisfactory installation of the complete system.
2. All equipment and components shall be installed in strict compliance with each manufacturer's recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes before beginning system installation. Refer to the riser/connection diagram for all specific system installation/termination/wiring data.
3. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place. (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

F. Conduit and Wire:

1. Conduit:
 - a. Conduit shall be in accordance with the National Electrical Code (NEC), local and state requirements.
 - b. All wiring exposed shall be installed in conduit or raceway. Conduit fill shall not exceed 40 percent of interior cross sectional area where three or more cables are contained within a single conduit.
 - c. Cable must be separated from any open conductors of power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, per NEC Article 760-29.
 - d. Wiring for 24 volt control, alarm notification, emergency communication and similar power-limited auxiliary functions may be run in the same conduit as

initiating and signaling line circuits. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.

- e. Conduit shall not enter any FACP, or any other remotely mounted control panel equipment or backboxes, except where conduit entry is specified by the FACP manufacturer.
- f. Conduit shall be 3/4 inch (19.1 mm) minimum.

2. Wire:

- a. All fire alarm system wiring must be new, unless specified herein.
- b. Wiring shall be in accordance with local, state and national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 16 AWG (1.02 mm) for initiating device circuits and signaling line circuits, and 14 AWG (1.32 mm) for notification appliance circuits.
- c. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
- d. Wiring used for the SLC multiplex communication loop shall be twisted and shielded unless specifically excepted by the fire alarm equipment manufacturer.
- e. All field wiring shall be completely supervised.

3. Terminal Boxes, Junction Boxes and Cabinets:

- a. All boxes and cabinets shall be UL listed for the intended purpose.

- 4. Initiating circuits shall be arranged to serve like categories (manual, smoke, waterflow). Mixed category circuitry shall not be permitted except on signaling line circuits connected to intelligent reporting devices.
- 5. The FACP shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution Panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 12 AWG. The FACP cabinet shall be grounded securely to either a cold water pipe or grounding rod. Provide lock-on device on breaker

G. Fire Alarm Control Panel:

- 1. Fire alarm control panel shall be Autocall, Notifier, or equal and shall contain a microprocessor based central processing unit (CPU). The FACP shall communicate with and control the following types of equipment used to make up the system: intelligent detectors, addressable modules, local and remote operator terminals, annunciators, and other system controlled devices.
- 2. Node Capacity and General Operation:
 - a. Each node shall provide, or be capable of, expansion to 198 intelligent addressable devices and 198 monitor/control modules for a total of 396 intelligent devices per system. FACP shall have two intelligent loops.
 - b. Each FACP node shall include a full featured operator interface control and annunciation panel which shall include a backlit Liquid Crystal Display (LCD), individual, color coded system status LEDs, and an alpha-numeric keypad for field programming and control of the node.

- c. All programming or editing of the existing programming the system shall be achieved without special equipment or interrupting the alarm monitoring functions of the fire alarm control panel.
- d. Each FACP node shall provide the following features:

Block Acknowledge	Printer Interface
Control-by-Time	Non-Alarm Module Reporting
Day/Night Sensitivity	Periodic Detector Test
Device Blink Control	Remote Page
Drift Compensation	Trouble Reminder
NFPA 72, Sensitivity	Upload/Download to PC
Test	computer
System Status Reports	Verification Counters
Security Monitor Points	Walk Test
Alarm Verification	Maintenance Alert

3. Loop Interface Board (LIB):

- a. Loop interface boards shall be provided to monitor and control each of the Signaling Line Circuit (SLC) loops in the network node. The loop interface board shall contain its own microprocessor and shall be capable of operating in local mode in the case of a failure in the main CPU of the control panel. In local mode, the loop interface board shall detect alarms and activate output devices on its own SLC loop.
- b. The LIB shall not require any jumper cuts or address switch settings to initialize SLC Loop operations.
- c. The loop interface board shall provide power to, and communicate with, all of the intelligent detectors and addressable modules connected to its SLC Loop over a single pair of wires. This SLC Loop shall be capable of operation as NFPA Style 4, Style 6, or Style 7.
- d. The LIB shall be able to drive two Style 4 SLC loops, each up to 10,000 ft. in length, for an effective loop span of 20,000 ft.
- e. The loop interface board shall receive analog information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular detector. The loop interface board software shall include software to automatically adjust and compensate for dust accumulation to maintain detector performance as it is affected by environmental factors. The analog information may also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.

- H. The LIB shall communicate with each intelligent addressable detector and addressable module on its SLC loop and verify proper device function and status. Communication with up to 198 intelligent devices shall be performed every 6 seconds or less.

1. Enclosures:

- a. Control panels shall be housed in UL listed cabinets suitable for surface or semi-flush mounting. Cabinets shall be corrosion protected, given a rust-resistant prime coat, and the manufacturer's standard finish.
- b. The back box and door shall be constructed of .060 steel with provisions for electrical conduit connections into the sides and top.

- c. The door shall provide a key lock and include a transparent opening for viewing all indicators. For convenience, the door shall have the ability to be hinged on either the right or left-hand side.
 - d. The control unit shall be modular in structure for ease of installation, maintenance, and future expansion.
2. FACP nodes shall be designed so that it permits continued local operation of remote transponders under both normal and abnormal network communication loop conditions. This shall be obtained by having transponders operate as local control panels upon loss of network communication.
3. FACP nodes shall be modular in construction to allow ease of servicing. Each CPU and transponder shall be capable of being programmed on site without requiring the use of any external programming equipment. Systems which require use of external programmers or change of EPROM's are not acceptable.
4. The CPU and associated equipment are to be protected so that they will not be affected by voltage surges or line transients including RFI and EMI.
5. Each peripheral device connected to the FACP node CPU shall be continuously scanned for proper operation. Data transmissions between network nodes, FACP CPUs, transponders, and peripheral devices shall be reliable and error free. The transmission scheme used shall employ dual transmission or other equivalent error checking techniques. Failure of any transponder or peripheral device to respond to an interrogation shall be annunciated as a trouble condition.
6. FACP Power Supplies:
 - a. Main power supplies shall operate on 120 VAC, 60Hz, and shall provide all necessary power for the FACP.
 - b. Each main supply shall provide 3.0 amps of usable notification appliance power, using a switching 24 VDC regulator.
 - c. The main power supply shall be expandable for additional notification appliance power in 3.0 ampere steps. Provide dedicated power supplies for signal circuit.
 - d. Each main power supply shall provide a battery charger for 60 hours of standby using dual-rate charging techniques for fast battery recharge. It shall charge 55 Amp hour batteries with-in a 48 hour period.
 - e. The supply shall provide a very low frequency sweep earth detect circuit, capable of detecting earth faults on sensitive addressable modules.
 - f. It shall provide meters to indicate battery voltage and charging current.
 - g. The main power supply shall be power-limited per 1995 UL864 requirements.
7. System Circuit Supervision:
 - a. Each FACP node shall supervise all circuits to intelligent devices, transponders, annunciators and peripheral equipment and annunciate loss of communications with these devices. The FACP CPU shall continuously scan the above devices for proper system operation and upon loss of response from a device shall sound an audible trouble, indicate which device or devices are not responding and print the information on the printer.
 - b. Sprinkler system valves, standpipe control valves, PIV, and main gate valves shall be supervised for off-normal position.
8. Field Wiring Terminal Blocks:
 - a. For ease of service, all wiring terminal blocks shall be the plug-in type and have sufficient capacity for 18 to 12 AWG wire. Fixed terminal blocks are not acceptable.

9. Field Programming:
 - a. The system shall be programmable, configurable and expandable in the field without the need for special tools or electronic equipment and shall not require field replacement of electronic integrated circuits.
 - b. All local FACP node programming shall be accomplished through the FACP keyboard.
 - c. All field-defined programs shall be stored in non-volatile memory.
 - d. The programming function shall be enabled with a password that may be defined specifically for the system when it is installed. Two levels of password protection shall be provided in addition to a key-lock cabinet. One level is used for status level changes such as zone disable or manual on/off commands. A second (higher-level) is used for actual change of program information.

10. Specific System Operations:
 - a. Smoke Detector Sensitivity Adjust: Means shall be provided for adjusting the sensitivity of any or all analog intelligent detectors in the FACP node from each system keypad or from the keyboard of the video terminal. Sensitivity range shall be within allowed UL limits.
 - b. Alarm Verification: Each of the intelligent addressable detectors in the system may be independently selected and enabled for alarm verification. Each FACP shall keep a count of the number of times each detector has entered the verification cycle. These counters may be displayed and reset by the proper operator commands.
 - c. System Point Operations:
 - 1) All devices in the FACP node may be enabled or disabled through the local keypad or video terminal.
 - 2) Any FACP node output point may be turned on or off from the local system keypad or the video terminal.
 - d. Point Read: The FACP node shall be able to display the following point status diagnostic functions without the need for peripheral equipment. Each point will be annunciated for the parameters listed:
 - 1) Device Status
 - 2) Device Type
 - 3) Custom Device Label
 - 4) Software Zone Label
 - 5) Device Zone Assignments
 - 6) Detector Analog Value
 - 7) All Program Parameters
 - e. System Status Reports: Upon command from a password-authorized operator of the system, a status report will generated, and printed, listing all local FACP system status.
 - f. System History Recording and Reporting: Each FACP node shall contain a history buffer that shall be capable of storing a minimum of 400 system events. Each local activation will be stored and time and date stamped with the actual time of the activation, until an operator requests that the contents be either displayed or printed. The contents of the history buffer may be manually reviewed, one event at a time, and the actual number of activations may also be displayed and or printed.
 - 1) The history buffer shall use non-volatile memory. Systems which use volatile memory for history storage are not acceptable.

- g. Automatic Detector Maintenance Alert: Each FACP node shall automatically interrogate each intelligent system detector and shall analyze the detector responses over a period of time.
 - 1) If any intelligent detector in the system responds with a reading that is below or above normal limits, then the system will enter the trouble mode, and the particular intelligent detector will be annunciated on the system display, network display and printed on the optional system printer. This feature shall in no way inhibit the receipt of alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.

I. Addressable Devices – General:

1. Addressable devices shall use simple to install and maintain decade (numbered 1 to 10) type address switches.
2. Addressable devices which use a binary address setting method, such as a Dip switch, are difficult to install and subject to installation error. This type of device is not an allowable substitute.
3. Detectors shall be intelligent (analog) and addressable, and shall connect with two wires to the FACP signaling line circuit.
4. Addressable smoke and thermal detectors shall provide dual alarm and power/polling LEDs. Both LEDs shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel, and both LEDs shall be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. If required, the LED flash shall have the ability to be removed from the system program. An output connection shall also be provided in the base to connect an external remote alarm LED.
5. Smoke detector sensitivity shall be set in the fire alarm control panel and shall be adjustable in the field through the field programming of the system. Sensitivity may be automatically adjusted by the panel on a time-of-day basis.
6. Using software in the FACP, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72, Chapter 7.
7. The detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper proof feature. Base shall include a sounder base with a built-in (local) sounder rated at 85 DBA minimum, a relay base and an isolator base designed for Class A applications.
8. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.
9. Detectors shall also store an internal identifying type code that the control panel shall use to identify the type of device (ION, PHOTO, THERMAL).
10. Detectors will operate in an analog fashion, where the detector simply measures its designed environment variable and transmits an analog value to the FACP based on real-time measured values. The FACP software, not the detector, shall make the alarm/normal decision, thereby allowing the sensitivity of each detector to be set in the FACP program and allowing the system operator to view the current analog value of each detector.
11. A magnetic test switch shall be provided to test each detector for 100 percent obscuration, reported to the FACP.
12. Addressable devices shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type

of device. LED(s) shall be provided that shall flash under normal conditions, indicating that the device is operational and is in regular communication with the control panel.

13. A magnetic test switch shall be provided to test detectors and modules. Detectors shall report an indication of an analog value reaching 100 percent of the alarm threshold.

J. Carbon Monoxide Detector

1. Features
 - a. Listed to UL standard 2075 for the Standard For Safety for Gas and Vapor Detector and Sensors
 - b. Tested to UL 2075 using UL 2034 Sensitivity limits for carbon monoxide gas
 - c. Surface mounts to a wall using the supplied enclosure rear housing
 - d. Flush mounts in a 2 x 4 (1-1/2 inch deep minimum) [5.08 cm x 10.16 cm (3.81 cm deep minimum)] single gang switch, or handy electrical box
 - e. Small, low profile, attractive unit in a white plastic case
 - f. Detector alarms at multiple levels of exposure to carbon monoxide based on time weighted averages of the gas present
 - g. Inexpensive, easy to install. Microcomputer control allows mostly automatic operation
 - h. Test & Reset switch conducts internal tests and actuates alarm relay
 - i. Visual display: Green - Normal operation
 - j. FLASHING Amber - Trouble Contact your installer or Macurco Tech Support
 - k. Red - Danger! Move to fresh air (hazardous condition is present)
 - l. Highly linear electrochemical sensor
 - m. N.O. or N.C. SPST Alarm Relay and N.C. SPST Trouble relay to connect to Alarm Control Panels
 - n. Buzzer: Produces repeating loud tone bursts during alarm, and chirps if sensor trouble is found
2. Specifications
 - a. Voltage: 9-32 VDC
 - b. Current (normal / alarm): 15mA / 35mA @ 9-32V
 - c. Size: 3-1/8 X 5-1/8 X 1-1/2 inch (7.94 x 13.02 x 3.81 cm)
 - d. Alarm Relay: SPST, 100mA, 40VDC
 - e. Trouble Relay: SPST, 100mA, 40VDC
 - f. Buzzer Rating: 85 dBA at 10 Feet
 - g. Shipping Weight: One pound
 - h. Operating Temp. Range: 40°F (4.4°C) to 100°F (37.8°C)
 - i. Alarm Setting: Per UL 2034
 - j. Color: White
 - k. Designed for use with a UL Listed Fire Alarm/Burglary Control Panel
 - l. End-of-Life Indication: 10 years after installation
3. Manufacturer:
 - a. Macurco CM-E1
 - b. Or equal

K. Addressable Pull Box (manual station):

1. Addressable pull boxes shall, on command from the control panel, send data to the panel representing the state of the manual switch and the addressable communication module status. They shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key.
2. All operated stations shall have a positive, visual indication of operation and utilize a key type reset.
3. Manual stations shall be constructed of Lexan with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches or larger.
4. Stations shall be suitable for surface mounting or semiflush mounting as shown on the plans, and shall be installed not less than 42 inches, nor more than 48 inches above the finished floor.
5. Manual pull stations shall be of the double action type.

L. Intelligent Photoelectric Smoke Detector:

1. The detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.

M. Intelligent Thermal Detectors:

1. Thermal detectors shall be intelligent addressable devices rated at 135 degrees Fahrenheit (58 degrees Celsius) and have a rate-of-rise element rated at 15 degrees F (9.4 degrees C) per minute. It shall connect via two wires to the fire alarm control panel signaling line circuit. Up to 99 intelligent heat detectors may connect to one SLC loop.

N. Intelligent Duct Smoke Detector:

1. The duct smoke detector housing shall accommodate intelligent photoelectric detector, of that provides continuous analog monitoring and alarm verification from the panel.
2. When sufficient smoke is sensed, an alarm signal is initiated at the FACP, and appropriate action taken to change over air handling systems to help prevent the rapid distribution of toxic smoke and fire gases throughout the areas served by the duct system.

O. Duct mounted carbon monoxide detector:

1. Manufactured by Air Products and Controls Model SL-701 or Equal
2. Product Specifications
Voltages available: 230VAC, 115VAC, 24VAC, 24VDC

APPROVALS

Electrochemical Carbon Monoxide Sensor is a UL Recognized component in accordance with the requirements of UL2034. Also meets EN50291 requirements. SL-2000 Series Duct Smoke Detector Fire Alarm Certifications referenced side one: UL & CUL Listed (UL268A, UROX, UROX7) File # S2829 CSFM Listed (3240-1004:105); MEA Accepted (73-92-E, VOL. 27)

SAMPLING TUBES Provide required length for duct coordinate with HVAC drawings

Sectional sampling tube
Metal sampling tube for 6" to 2.5' duct width
Metal sampling tube for 2.5' to 5.0' duct width
Metal sampling tube for 5.0' to 10.0' duct width

ACCESSORIES

MSR-50/CO remote accessory
TG-701 aerosol test gas
T-PB power supplies
WP-2000 weatherproof enclosure
(All available from Air Products and Controls Inc.)

POWER REQUIREMENTS

Input Power	Standby Current	Alarm Current
24VAC	55mA	190mA
24VDC	14mA	68mA
115VAC	22mA	32mA
230VAC	12mA	18mA

RELAY CONTACT RATING:

Alarm Contacts	Resistive load: 2 sets form "C" rated at 10 Amps @ 115VAC Resistive load: 1 set form "A" rated at 2 Amps
Trouble Contacts	Resistive load: 1 set form "C" rated at 10 Amps @ 115VAC

AIR VELOCITY

100 to 4,000 ft. /min.

AMBIENT TEMPERATURE

32°F to 158°F (0°C to 70°C)

HUMIDITY

10% to 85% RH Non-Condensing / Non-Freezing

WIRING

Solid or stranded: #12 to #22 AWG terminals

MATERIAL

Grey plastic back box, clear plastic cover (Makrolon 94V-0)
Do not expose to corrosive atmospheres.

DIMENSIONS

13 ½" L x 4 ½" W x 2 ¼" D

MAX. NET WT.:

2 ½ lbs.

HARDWARE

7" exhaust tube, FAST Tube starter sampling tube, sampling tube end cap, mounting template, and mounting hardware included.

P. Addressable Dry Contact Monitor Module:

1. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional alarm initiating devices (any N.O. dry contact device) to one of the fire alarm control panel SLC loops.
2. The monitor module shall mount in a four in. square, 2-1/8 in. deep electrical box.
3. The IDC zone may be wired for Style D or Style B operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.

4. For difficult to reach areas, the monitor module shall be available in a miniature package and shall be no larger than 2-3/4 in. x 1-1/4 in. x 1/2 in. This version need not include Style D or an LED.

Q. Two-Wire Detector Monitor Module:

1. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional two wire smoke detectors or alarm initiating devices (any N.O. dry contact device).
2. The two-wire monitor module shall mount in a four in. square, 2-1/8 in. deep electrical box or with an optional surface backbox.
3. The IDC zone may be wired for Class A or B (Style D or Style B) operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.

R. Addressable Control Module:

1. Addressable control modules shall be provided to supervise and control the operation of one conventional NACs of compatible, 24 VDC powered, polarized audio/visual notification appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contract relay.
2. The control module shall mount in a standard four in. square, 2-1/8 in. deep electrical box, or to a surface mounted backbox.
3. The control module NAC may be wired for Style Z or Style Y (Class A/B) with up to 1 amp of inductive A/V signal, or two amps of resistive A/V signal operation, or as a dry contact (Form-C) relay. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100 percent of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.
4. Audio/visual power shall be provided by a separate supervised power loop from the main fire alarm control panel or from a supervised, UL listed remote power supply.
5. The control module shall be suitable for pilot duty applications and rated for a minimum of .6 amps at 30 VDC.

S. Isolator Module:

1. Isolator modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC loop. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop. At least one isolator module shall be provided for each floor or protected zone of the building.
2. If a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the isolator module shall automatically reconnect the isolated section.
3. The isolator module shall not require any address setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.
4. The isolator module shall mount in a standard 4-inch deep electrical box or in a surface mounted backbox. It shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

T. LCD Alphanumeric Display Annunciator:

1. The alphanumeric display annunciator shall be a supervised, backlit LCD display containing a minimum of eighty characters for alarm annunciation in clear English text.
2. The LCD annunciator shall display all alarm and trouble conditions from either the network node or complete network, via the INA.
3. Up to 32 LCD annunciators may be connected to a specific (terminal mode) EIA 485 interface. LCD annunciators shall not reduce the annunciation capacity of the system. Each LCD shall include vital system wide functions such as, system acknowledge, silence and reset.
4. LCD display annunciators shall mimic the local control panel 80 character display or network annunciator and shall not require special programming.

U. Batteries and External Charger:

1. Battery:
 - a. Batteries shall be 12 volt, Gell-Cell type.
 - b. The battery shall have sufficient capacity to power the fire alarm system for not less than 60 hours plus 10 minutes of alarm upon a normal AC power failure.
 - c. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks for refilling, spills and leakage shall not be required.

V. Audio/Visual Unit (Xenon Strobe):

1. Combination horn strobe units - Provide Non-Addressable 75 Cd, Red Sync. Two Wire. Comprised of a 24 VDC Xenon Flash Tube entirely solid state. The unit shall require a sync. Control module. Provide True 75 Cd from all axis.
2. Combination horn strobe units - Provide Non-Addressable 110 Cd, Red Sync. Two-Wire. Comprised of a 24 VDC Xenon Flash Tube entirely solid state. The unit shall require a sync. Control module. Provide True 110 Cd from all axis.
3. Visual only – Provide Non-Addressable 15 Cd, Red Sync. Two-Wire comprised of a 24 VDC Xenon flash tube entirely solid state.

W. Magnetic Door Holders:

1. Provide Semi-Flush Wall Mounted, 120 V. with catch plate.

X. Provide clear plastic covers with local audible alarm for pull stations in apparatus area, and where indicated on drawings, or required by fire department.

Y. Cellular Alarm Transmission:

1. Provide a cellular RF communicator equal to Starlink #SLE-LTEV-CFB and all programming antennae, battery back-up and testing to connect to a UL listed central station. Cellular communicator shall report Contact ID to report by device. Provide one year of monitoring by a UL listed central station.

Z. Key Repository Box

1. Provide a key repository box (es) as shown on drawings and in accordance with fire department requirements.
2. Key repository boxes shall be knox Vault model 4432
3. Provide Key repository box for fire fighters

4. Color black with red reflective 3M tape
5. Knox box shall be flush mount where mounted to building and surface mounted where located at site gates.

AA. Intelligent Addressable Low Frequency Sounder Base:

1. Specifications:
 - a. Diameter:
 - 1) B501: 4.1" (104 mm).
 - 2) B224BI, B224RB, B210LP: 6.1" (155 mm).
 - 3) B200S/SR: 6.875" (17.46 cm).
 - b. Wire Gauge:
 - 1) B224BI, B224RB: 14 to 24 AWG.
 - 2) B210LP, B501, B200S/SR: 12 to 24 AWG.
 - c. Temperature Range:
 - 1) B224BI, B224RB, B200S/SR: 32°F to 120°F (0°C to 49°C).
 - 2) B210LP, B501: -4°F to 150°F (-20°C to 66°C).
 - d. Humidity range: 10% to 93% RH, non-condensing.
 - e. System temperature and humidity ranges: This system meets NFPA requirements for operation at 0°C to 49°C (32°F to 120°F); and at a relative humidity (noncondensing) of 85% at 30°C (86°F) per NFPA, and 93% ± 2% at 32°C ± 2°C (89.6°F ± 1.1°F) per ULC. However, the useful life of the system's standby batteries and the electronic components may be adversely affected by extreme temperature ranges and humidity. Therefore, it is recommended that this system and all peripherals be installed in an environment with a nominal room temperature of 15°C to 27°C (60°F to 80°F).
2. Electrical Ratings:
 - a. FOR B200S/SR:
 - 1) External supply voltage: 16 to 33 VDC (VFWR)
 - 2) Standby current: 500 µA maximum.
 - 3) Alarm current:
 - 4) B200S: 25 mA maximum at high-volume setting; 15 mA maximum at low-volume setting.
 - 5) B200SR: 35 mA maximum.
 - 6) SLC operating voltage: 15 to 32 VDC.
 - 7) SLC standby current: 300 µA.
 - 8) Sound output: measured in a UL reverberant room at 10 feet, 24 Volts (continuous tone).
 - 9) B200S, high-volume: Greater than 85 dBA minimum.
 - 10) B200S, low-volume: Greater than 75 dBA minimum.
 - 11) B200SR: Greater than 85 dBA minimum.
 - b. FOR B224RB, B224BI:
 - 1) Operating voltage: 15 to 32 VDC (powered by SLC).
 - 2) Standby ratings: <500 µA maximum @ 24 VDC.
 - 3) Set time (B224RB only): short delay 55 to 90 msec; long delay 6 to 9 seconds.
 - 4) Reset time (B224RB only): 20 msec maximum.
 - 5) Relay characteristics (B224RB only): two-coil latching relay; one Form-C contact; ratings (UL/CSA): 0.9 A @ 125 VAC, 0.9 A @ 110 VDC, and 3.0 A @ 30 VDC.

BB. Testing:

1. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.
2. Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire alarm systems. Examples of qualified personnel shall be permitted to include, but shall not be limited to, individuals with the following qualifications:
 - a. Factory trained and certified.
 - b. National Institute for Certification in Engineering Technologies (NICET) fire alarm certified.
 - c. International Municipal Signal Association (IMSA) fire alarm certified.
 - d. Certified by a state or local authority.
 - e. Trained and qualified personnel employed by an organization listed by a national testing laboratory for the servicing of fire alarm systems.
3. Pretesting: Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved.
4. Final Test Notice: Provide a 10-day minimum notice in writing when the system is ready for final acceptance testing.
5. Minimum System Tests: Test the system according to the procedures outlined in NFPA 72.
6. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.
7. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log.
8. Final Test, Certificate of Completion, and Certificate of Occupancy:
 - a. Test the entire system 100 percent including devices in the presence of the Authority Having Jurisdiction in order to obtain a certificate of occupancy.
9. Fire Alarm Testing and Maintenance Agreement
 - a. Provide a one-year inspection and testing agreement in accordance with local Fire Department requirements and NFPA 72 recommendations. The holder of the testing and maintenance contract shall be a properly licensed and NRTL certified provider of Fire Alarm services and acceptable to the Fire Department.
 - b. Fire alarm testing agreement shall provide for a minimum of four inspections per year. Upon completion of each test, list actual devices checked. Provide a report to the Owner.

CC. Training:

1. Provide four hours Owner training with Owner's Representative.

2.18 SURGE PROTECTION DEVICES

A. SCOPE

1. This section describes the materials and installation requirements for surge protective devices (SPD) for the protection of all main service and panelboards.

B. SUBMITTALS

1. Submit shop drawings and product information for approval and final documentation in the quantities listed according to the Conditions of the Contract. All transmittals shall be identified by customer name, customer location, and customer order number.
2. Submittals shall include UL 1449 3rd Edition Listing documentation verifiable by visiting www.UL.com, clicking "Certifications" link, searching using UL Category Code: VZCA and VZCA2:
 - a. Short Circuit Current Rating (SCCR)
 - b. Voltage Protection Ratings (VPRs) for all modes
 - c. Maximum Continuous Operating Voltage rating (MCOV)
 - d. I-nominal rating (I-n)
 - e. SPD shall be UL listed and labeled as Type 1 or Type 4 intended for Type 1 or Type 2 applications
3. Upon request, an unencapsulated but complete SPD formally known as TVSS shall be presented for visual inspection.
4. Minimum of ten (10) year warranty

C. RELATED STANDARDS

1. IEEE C62.41.1, IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits,
2. IEEE C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits,
3. IEEE C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
4. National Electrical Code: Article 285
5. UL 1283 - Electromagnetic Interference Filters
6. UL 1449, Third Edition, effective September 29, 2009 – Surge Protective Devices

D. QUALITY ASSURANCE

1. Manufacturer Qualifications: Engage a firm with at least 5 years' experience in manufacturing transient voltage surge suppressors.
2. Manufacturer shall be ISO 9001 or 9002 certified.
3. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of ten (10) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
4. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

E. DELIVERY, STORAGE AND HANDLING

1. Handle and store equipment in accordance with manufacturer's Installation and Maintenance Manuals. One (1) copy of this document to be provided with the equipment at time of shipment.

F. MANUFACTURERS

1. Provide an internally mounted Surge Protective Devices (SPD) formerly called Transient Voltage Suppressor (TVSS) by:
 - a. Siemens Industry.
 - b. Current Technology
 - c. LEA
 - d. Liebert
 - e. APT
 - f. Or equal

G. ELECTRICAL DISTRIBUTION EQUIPMENT

1. Service Entrance
 - a. SPD shall be UL 1449 labeled as Type 1 or Type 4 intended for Type 1 or Type 2 applications, verifiable at UL.com, without need for external or supplemental overcurrent controls. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal overtemperature controls. SPDs relying upon external or supplementary installed safety disconnectors do not meet the intent of this specification.
 - b. SPD shall be factory installed integral to electrical distribution equipment.
 - c. SPD shall be UL labeled with 20kA I-nominal (I-n)
 - d. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR).
 - e. Standard 7 Mode Protection paths: SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
 - f. True 10 Mode Protection paths: SPD shall provide “directly connected protection elements” between all possible modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
 - g. SPD shall be connected external of the distribution equipment with an appropriately sized 200kA SCCR rated disconnect.
 - h. SPD shall meet or exceed the following criteria:
 - 1) Maximum 7-Mode surge current capability shall be 300kA per phase.
 - 2) Maximum 10-Mode surge current capability shall be 300kA per phase.
 - 3) UL 1449 - Third Edition Revision; effective September 29, 2009 Voltage Protection Ratings shall not exceed the following:

<u>VOLTAGE</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>	<u>L-L</u>	<u>MCOV</u>
208Y/120	800V	800V	800V	1200V	150V
 - i. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

<u>System Voltage</u>	<u>Allowable System Voltage Fluctuation (percent)</u>	<u>MCOV</u>
208Y/120	25 percent	150V
 - j. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
 - k. Suppression components shall be heavy duty ‘large block’ MOVs, each exceeding 30mm diameter.
 - l. SPD shall include a serviceable, replaceable module.
 - m. SPD shall be equipped with the following diagnostics:

- 1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 - 2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).
 - 3) Form C dry contacts
 - 4) Optional – Surge Counter
 - 5) No other test equipment shall be required for SPD monitoring or testing before or after installation.
- n. SPD shall have a response time no greater than 1/2 nanosecond.
- o. SPD shall have a 10 year warranty.

2. Distribution Panel

- a. SPD shall be UL 1449 labeled as Type 4 intended for Type 1 or Type 2 applications, verifiable at UL.com, without need for external or supplemental overcurrent controls. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal overtemperature controls. SPDs relying upon external or supplementary installed safety disconnectors do not meet the intent of this specification.
- b. SPD shall be factory installed integral to electrical distribution equipment.
- c. SPD shall be UL labeled with 20kA I-nominal (I-n)
- d. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR).
- e. Standard 7 Mode Protection paths: SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
- f. SPD shall be connected to the buss of the distribution equipment with an appropriately sized 200kA SCCR rated disconnect.
- g. SPD shall meet or exceed the following criteria:
 - 1) Maximum 7-Mode surge current capability shall be 100kA per phase.
 - 2) Maximum 10-Mode surge current capability shall be 150kA per phase.
 - 3) UL 1449 - Third Edition Revision; effective September 29, 2009, Voltage Protection Ratings shall not exceed the following:

<u>VOLTAGE</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>	<u>L-L</u>	<u>MCOV</u>
208Y/120	800V	800V	800V	1200V	150V

- a) UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

<u>System Voltage</u>	<u>Allowable System Voltage Fluctuation (percent)</u>	<u>MCOV</u>
208Y/120	25 percent	150V

- h. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
- i. Suppression components shall be heavy duty 'large block' MOVs, each exceeding 30mm diameter.
- j. SPD shall include a serviceable, replaceable module.
- k. SPD shall be equipped with the following diagnostics:
 - 1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 - 2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).

- 3) Form C dry contacts
- 4) Optional – Surge Counter
- 5) No other test equipment shall be required for SPD monitoring or testing before or after installation.
- l. SPD shall have a response time no greater than 1/2 nanosecond.
- m. SPD shall have a 10 year warranty.
- n. Branch Panels
- o. The panelboard shall be UL 67 Listed and the SPD shall be UL 1449 labeled as Type 1 or as Type 4 intended for Type 1 or Type 2 applications.
- p. The unit shall be top or bottom feed according to requirements. A circuit directory shall be located inside the door.
- q. SPD shall meet or exceed the following criteria:
 - 1) Maximum 7-Mode surge current capability shall be 100kA per phase.
 - 2) Maximum 10-Mode surge current capability shall be 150kA per phase.
 - 3) UL 1449 - Third Edition Revision; effective September 29, 2009, Voltage Protection Ratings shall not exceed the following:

<u>VOLTAGE</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>	<u>L-L</u>	<u>MCOV</u>
208Y/120	800V	800V	800V	1200V	150V
- r. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

<u>System Voltage</u>	<u>Allowable System Voltage Fluctuation (percent)</u>	<u>MCOV</u>
208Y/120	25 percent	150V
- s. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
- t. Suppression components shall be heavy duty ‘large block’ MOVs, each exceeding 30mm diameter.
- u. SPD shall include a serviceable, replaceable module.
- v. SPD shall be equipped with the following diagnostics:
 - 1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 - 2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).
 - 3) Form C dry contacts
 - 4) Optional – Surge Counter
 - 5) No other test equipment shall be required for SPD monitoring or testing before or after installation.
- w. SPD shall have a response time no greater than 1/2 nanosecond.
- x. SPD shall have a 10 year warranty.
- y. The unit shall have removable interior.
- z. The main bus shall be [copper] [aluminum] and rated for the load current required.
- aa. The unit shall include a 200 percent rated neutral assembly with copper neutral bus.
- bb. The unit shall be provided with a safety ground bus.
- cc. The field connections to the panelboard shall be main lug or main breaker.
- dd. The unit shall be constructed with flush or surface mounted trim and shall be in a NEMA Type 1 enclosure.

H. INSTALLATION

1. Install per manufacturer's recommendations and contract documents.

I. ADJUSTMENTS AND CLEANING

1. Remove debris from installation site and wipe dust and dirt from all components.
2. Repaint marred and scratched surfaces with touch up paint to match original finish.

J. TESTING

1. Check tightness of all accessible mechanical and electrical connections to assure they are torqued to the minimum acceptable manufacture's recommendations.
2. Check all installed panels for proper grounding, fastening and alignment.

K. WARRANTY

1. Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.

2.19 AUTOMATED LIGHTING CONTROL SYSTEM

A. General: Summary

1. Section Includes:
 - a. Addressable Networked Light Management System.

B. References

1. National Fire Protection Association (NFPA)
2. cULus Listing/Certification
 - a. Certified as Energy Management Equipment (UL 916)
 - b. Certified as Emergency Lighting Equipment (UL 924)
 - c. Meet Heat and Smoke Release for Air-Handling Spaces (UL 2043)
3. Federal Communications Commission (FCC) / Industry Canada (IC)
4. California Energy Commission (CEC)
5. Local Building Codes

C. System Description

1. Lighting Control System includes computer-based software that provides control, configuration, monitoring and reports. System includes the following components:
 - a. Central Control Unit
 - b. System Server
 - c. 0-10V Dimming, Fixed Output Ballasts or 0-10V LED Drivers
 - d. System Field Devices (Input and Output Modules)
 - e. Lighting Control System Software
 - f. Lighting Controllers
 - g. Communication Wire
 - h. Occupancy sensors

- i. Photo sensors
- j. Power packs
- k. Lighting control panels
- l. Interface to audio visual equipment
- m. Interface to BACnet
- n. Interface to Tridium Niagara
- o. Incandescent low-voltage dimming modules

D. Submittals

1. General: Provide submittals per 2.20, D (-2-9) below:
2. Bill of Materials: Complete list of all parts needed to fully install selected system components.
3. Product Data: For each type of product indicated.
4. Shop and Wiring Drawings: Submit shop drawings detailing control system, as supplied, including one-line diagrams, wire counts, coverage patterns, interconnection diagrams showing field-installed wiring and physical dimensions of each item.
5. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
 - a. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
 - b. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.
6. Software Operational Documentation:
 - a. Software operating and upgrade manuals.
 - b. Program Software Backup: On compact disc or DVD, complete with data files.
 - c. Printout of software application and graphic screens, or upon request, a live demonstration of Control, Configure and Analyze functionality or a video demonstrating above stated system capabilities.
7. Installation Instructions: Manufacturer's installation instructions.
8. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.
9. Warranty: Copy of applicable warranty.

E. Quality Assurance

1. Installer Qualifications: Installer shall be one who is experienced in performing the work of this section, and who has specialized in installation of work similar to that required for this project.
2. Manufacturer Requirements: The manufacturer shall have a minimum of 10 years' experience manufacturing networked lighting control systems and shall provide 24/7 telephone support by qualified technicians.
3. Contractor shall ensure that lighting system control devices and assemblies are fully compatible and can be integrated into a system that operates as described in the lighting control notes on drawings and as described within this specification. Any incompatibilities between devices, assemblies, and system controllers shall be resolved between the contractor and the system provider to ensure proper system operation and maintainability.

4. Performance Requirements: provide all system components that have been manufactured, assembled, and installed to maintain performance criteria stated by manufacturer without defects, damage, or failure.
5. Performance Testing Requirements
 - a. Manufacturer shall 100 percent test all equipment prior to shipment. Sample testing is not acceptable.
6. Code Requirements
 - a. System Control Unit and System Field Devices shall be cULus listed and certified.
 - b. All system components shall be FCC /IC compliant.
 - c. All system components shall be installed in compliance with National Electrical Codes and Canadian Electrical Code.
 - d. Building Codes: All units shall be installed in compliance with applicable, local building codes.
7. ISO Certification: System components shall be manufactured at ISO-9000 certified plants.
8. The system supplied shall be listed on the most up to date Mass Save Network Lighting Controls Qualified products list. The manufacturer is responsible for complying with Mass Save Network Lighting Controls project qualifications and issuing all required documentation to qualify for the project incentive.

F. COORDINATION

1. Coordinate lighting control components to form an integrated interconnection of compatible components.
 - a. Match components and interconnections for optimum performance of lighting control functions.
 - b. Display graphics showing building areas controlled; include the status of lighting controls in each area.

G. Delivery, Storage & Handling

1. Ordering: Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
2. Delivery: Deliver materials in manufacturer's original, unopened, undamaged packaging with intact identification labels.
3. Storage and Protection: Store materials away from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer.

H. Warranty

1. On-going system expansion, service and support shall be available from multiple factory certified vendors. Recommended service agreements shall be submitted at the time of bid complete with manufacturers suggested inventory and pricing for system parts and technical support labor.
2. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship within specified warranty period.
3. Manufacturer's Warranty: All equipment shall be warranted free of defects in materials and workmanship.

- a. Warranty Period: All system hardware components shall have full warranty (non-prorated) for at least four years and all software components shall carry a warranty of 90 days from date of installation.
- b. Owner Rights: Manufacturer's warranty is in addition to, not a limitation of, other rights the Owner may have under contract documents, or warranties of third party component manufacturers.

I. Basis of Design Products

1. Controls: ENCELIUM Energy Management System by Legrand
2. Sensors: ENCELIUM Sensors by Legrand & Hubbell Building Automation, Inc.

J. Acceptable Alternate Manufacturers

1. Controls: Lutron, Sensor Switch, Crestron, or equal.
2. Sensors: Lutron, Sensor Switch, Watt Stopper, Leviton, Cooper or equal.

K. System Performance Requirements

1. This specification is intended to fully describe all of the design, engineering, programming, hardware, software, ancillary devices and associated technical services required to provide a building-wide networked lighting control system. This system is specified to perform scheduled and automated lighting control sequences.
2. The lighting control "system" shall include a fully distributed WAN/LAN network of global controller/routers, individually addressable System Field Devices, sensors, switches, relays and other ancillary devices required for a complete and operable system. The system WAN/LAN shall be commissioned by ENCELIUM personnel or other ENCELIUM certified commissioning contractors.
3. The basis of system design shall utilize non-propriety industry standard 0-10V dimming or fixed output ballasts and/or 0-10V LED drivers, occupancy sensors, and daylight sensors.
4. On-going system expansion, service and support shall be available from multiple factory certified vendors. Recommended service agreements may be submitted at the time of bid complete with manufacturers suggested inventory and pricing for system parts and technical support labor.
5. Lighting Control Software: The system shall offer two separate levels of lighting control: one personal lighting control for the average building occupant to control and adjust basic lighting functions in their workspace, and two central lighting control for the facility lighting administrator to perform energy management, configuration maintenance, monitoring operations, and providing support to building occupants.
 - a. Native central control software shall be utilized for energy reporting status and complete programming without the need for any third party hardware or software. Systems that require any third party linked software or graphics shall be unacceptable.
 - b. Software shall provide information on general system settings via mouse click on a floor plan. Left clicking over a device on the graphical software interface shall show a description of the selected device/function attribute.
6. Central Lighting Control:
 - a. Shall provide an Interactive, Web-based graphical user interface (GUI) showing floor plans and lighting layouts that are native to the lighting control software. The only means required to program and operate the lighting control system shall be

programmed and operated from a user interface that is based on a plan view graphical screen on the user's computer or the lighting control system's main computer. Shall include the navigational features listed below to allow for user's orientation within the controlled space, geographic heading and/or landmarks:

- 1) Interactive
 - 2) Vector based
 - 3) Zoom
 - 4) Rotate
 - 5) Pan
 - 6) Tilt
- b. Shall allow building operator to navigate through an entire facility both in two- dimensional and three-dimensional multi-floor view, allowing for fast and easy navigation.
 - c. Three-dimensional view shall exclude walls and other structural features to avoid shadowing and cluttering of the plan view.
 - d. All programming, assignments of lighting loads to control strategies, lighting status and lighting energy reporting shall be native to the software and executed from this GUI. Editing shall be available from this GUI in a drag and drop format or from drop down menus without the need for any third party software. Systems that utilize or require third party linked graphics are unacceptable. The GUI shall continuously indicate the status of each connected device on the system and a warning indicator on the software if a device goes offline. Systems requiring spreadsheet editing for programming and that don't offer real time feedback are not acceptable.
 - e. Software settings and properties shall be selectable per individual device, room based, floor based or global building based.
 - 1) Lighting Control Software interface shall provide current status and enable configuration of all system zones including selected individual fixture availability, current light level, maximum light level, on/off status, occupancy status, and emergency mode (response to an emergency signal) status.
 - f. Shall have the ability to display various lighting system parameters such as Lighting status (ON/OFF); Lighting levels, Load shedding status, or Lighting energy consumption, Occupancy status in a colorized gradient ("weather" map) type of graphical representation.
 - g. Energy Analysis data shall be exportable in a CSV or similar format.
 - h. Shall allow import of native AutoCAD files.
7. Reports: Reporting feature shall be native to the lighting control software and capable of reporting the following parameters for each device and zone individually without requiring any third party hardware and software:
 - a. Energy consumption broken down by energy management strategy.
 - b. Energy demand broken down by energy management strategy.
 - c. Occupancy data by zone.
 - d. Building wide occupancy status
 - e. Lighting energy consumption in a color gradient ("weather map" type) view
 - f. Energy performance reports shall be printable in a printer friendly format and downloadable for use in spreadsheet applications.
 8. Personal Lighting Controls: The Personal Control Software interface shall provide current status and enable each user with the ability to dim and brighten lights, and turn them on and off by individual fixture or zone. The Software shall offer user configurable light

- scenes, which may be programmed and then selected via the Software. Personal lighting control shall be available in open/private office environments.
9. Daylight Harvesting (Light Regulation Averaging): In a photo sensor-equipped system, the Central Controller Unit shall rationalize changes to light levels when ambient (natural) light is available and shall maintain a steady light level when subjected to fluctuating ambient conditions where dimming ballasts and/or drivers exist. Areas equipped with fixed output ballasts and/or drivers shall energize when natural light falls below foot-candle levels specified. System shall utilize light level inputs from common and/or remote sensor locations to minimize the number of photo sensors required. The System shall operate with multiple users in harmony and not react adversely to manual override inputs.
 10. Time Clock Scheduling: The system shall be programmable for scheduling lights on or off via the Lighting Control Software interface.
 - a. Support for BACnet Time Schedule Object: This allows the export of Lighting Control time schedules to BACnet devices and vice versa in the event of Lighting Control System's integration with BACnet.
 - b. Override: Manual adjustments via lighting controllers or personal control software shall temporarily override off status imposed by time clock schedule.
 - c. Response to Power Failure: In the event of a power failure, the time clock shall execute schedules that would still be in progress had they begun during the power outage.
 - d. Flick Warning: Prior to a scheduled lights-off event or expiry of a temporary override, the system shall provide two short light level drops as a warning to the affected occupants. Flick warning time shall have the ability to be programmed via software between one and five minutes.
 11. Load Shed Mode: An automatic load shedding mode shall be available where, when activated through the system, the control unit will reduce its output to a programmable maximum electrical demand load. The system shall not shed more load than required and load shedding priority shall be centrally configurable by control zone or by common uses (i.e., all hallways can be treated as one load shed group), with subsequent load shed priority groupings being utilized until the required defined load has been shed, for either a defined period, or until the demand response input has been removed. Systems that simply select a "load shed scene" whereby there is no guarantee that the defined required load will actually be shed are not acceptable.
 12. Emergency Mode: There shall be a mode, when activated through the system, that will immediately adjust lights to full light output and retain that level until the mode is deactivated in the event of an emergency. This setting shall override all other inputs. The system shall interface with the building of life safety transfer switch, fire alarm control panel, and security system control panel.
 13. Addressing: All ballasts and/or drivers shall be centrally addressable, on a per fixture or multiple fixtures/zone basis, through the Central Control Software. The basis of design shall utilize industry standard 0-10V Dimming, Fixed Output Ballasts and/or 0-10V LED Drivers connected to an Output Module. To simplify ongoing maintenance, the system shall not require manual recording of addresses for the purpose of commissioning or reconfiguration.
 14. Programmable Task Tuning: Maximum light level programmability shall be available by individual fixture.
 15. Unoccupied State: The system shall provide two states when occupancy status is vacant as per an occupancy sensor: lights turn off or lights adjust to configurable (dimmed) light level.

16. Occupied State: The system shall be capable of creating “comfort” or “support” zones to ensure that occupants are not isolated by turning off lights in adjacent areas for occupant comfort and safety, such as a hallway path to exit the premises.
17. The Automated Lighting Control System (ALCS) BACnet Interface shall share the following information with the BACnet enabled Building Automation System and other systems listed below:

<u>Property</u>	<u>BACnet Type</u>	<u>Description</u>
Lighting Load	Analog Value*	Reports the total lighting load of the ALS, defined in Watts
Light Zone State	Binary Value*	State of the defined lighting zone - ON or OFF
Light Zone Dimming	Analog Value*	Light output level of the defined lighting zone, from 100 percent (maximum light output) to 0 percent (minimum light output)
Emergency System State	Binary Input	State of the emergency alarm system: alarm activated or alarm not activated
Fire Alarm State	Binary Input	State of the fire alarm system: alarm activated or alarm not activated
Security System State	Binary Input	State of security alarm system: alarm activated or alarm not activated
Occupancy State	Binary Output	State of the defined occupancy sensor – occupancy detected or not detected
Sheddable Load	Analog Output	Reports the total lighting load available for load reduction according to ALS, defined in Watts
Shed Status	Analog Output	Reports the total current load reduction achieved according to ALS defined

		prioritization, defined in Watts
Shed Request	Analog Input	Requested total amount of load reduction, defined in Watts or as a percentage of sheddable load
Sheddable Load (Group)	Analog Output	(As above, unprioritized for the selected group)
Shed Status (Group)	Analog Output	(As above, unprioritized for the selected group)
Shed Request (Group)	Analog Input	(As above, unprioritized for the selected group)
18.	LAN Operations: System shall be capable of operating independent of building's existing network infrastructure if desired and shall not rely on tenant supplied PCs for operation. Network infrastructure shall only be utilized for Personal Control Software.	
19.	Firewall Security: Firewall technology shall be utilized to separate tenants from the lighting control network.	
20.	Lamp Burn In: The system software shall not permit dimming of new lamps prior to completion of lamp manufacturer 100 hour recommended accumulated operation at full brightness.	
21.	Re-configurability: The assignment of individual fixtures to zones shall be centrally configurable by Central Control Software such that physical rewiring will not be necessary when workspace reconfiguration or re-zoning is performed. Removal of covers, faceplates, and ceiling tiles. shall not be required.	
22.	Automatic Control Parameters: Occupancy sensor time delays shall be configurable through software. Light level sensor parameters shall be configurable through software.	
23.	Automatic Time Adjustment: System shall automatically adjust for leap year and daylight savings time and shall provide weekly routine and annual holiday scheduling.	
24.	Contact closure input: System shall be capable of receiving a momentary and sustained contact closure input from third party sources to control lighting zones.	
25.	The light management system shall interface digitally with the building automation system via BACnet/IP and Tridium Niagara AX interface. The lighting control system shall communicate the status of output devices (lighting loads) as well as input devices (dry contacts, switches, occupancy sensors, vacancy sensors, and photocells) over this connection allowing the building automation system to utilize lighting control system input devices such as occupancy sensors to determine if mechanical control zones are occupied for climate adjustments.	
26.	The system software shall provide a web based energy dashboard to show real time energy savings data and carbon footprint reductions.	
27.	Migration Plan to Control LED Fixtures	
a.	System shall be capable of migrating from the control of 0-10V Ballasts to 0-10V LED Drivers utilizing the same Output Modules without the need to change control hardware.	

L. Lighting Controllers

1. Description: The system shall include separate lighting controllers for each of the listed functionalities and at minimum meet listed electromagnetic, mechanical, electrical and data specifications:
 - a. Software configurable lighting controller that provides on/off switching and dimming control for up to three lighting zones/scenes per controller or more with allowable multi-gang configurations. Status is indicated by an LED display to indicate function, scene or zone. Allows manual override of the time schedule.
 - b. Manual dimming and/or switching lighting controller that provides local on/off and dimming control over at least three lighting zones. Allows manual dimming of light levels and override of the time schedule.
 - c. Scenes in the central control software shall be synchronized with the buttons on the lighting controller.
 - d. Lighting controllers shall fit in a standard Decorator style wall plate and may be ganged together.
2. General
 - a. Addressing: All controllers shall be individually addressable & reconfigurable via Central Control Software.
 - b. Shall provide local on/off or dimming control over lighting zones
 - c. Shall utilize a standard single-gang or multi-gang form factor
 - d. Shall have a terminal block that connects to lighting system with 18 AWG, polarity independent, CMP rated and low voltage wire
 - e. Shall be manufactured with push-in wire receptacles
 - f. LED's: All controllers shall feature LED's to indicate light on and light off status.
 - g. Color: All controllers shall meet NEMA WD1 color specifications.
 - h. Style: All controllers shall feature Decorator styling wall plates.
 - i. Lighting scenes reconfigure automatically based on scene changes from personal control software.
 - j. Industrial lighting controllers shall also be available for damp location applications.
 - k. Shall comply or exceed the following electromagnetic requirements:
 - 1) EN 61000-4-2
 - 2) EN 61000-4-4
 - 3) EN 61000-4-5
 - 4) FCC Part 15/ICES-003
3. Mechanical Specifications:
 - a. Dimensions: Shall meet NEMA WD-6 spec.
 - b. Maximum Operating Ambient Temperature: 60 deg C.
 - c. Mounts in standard size wall box suitable for multi gang installation or alternative of Low Voltage mounting bracket.
 - d. Suitable for use with Decorator style wall plates.
4. Electrical Specifications:
 - a. Class 2 Low Voltage device.
 - b. Power through interconnected 18 AWG cable with 2-pin header
5. Data Specifications:
 - a. Class 2 communication bus that uses prefabricated 18 AWG cable.

M. Wireless Site Lighting Control Module

1. The wireless site lighting control module shall extend the networked light management system's controls capability to a building's surroundings or site such as parking lots and short pathways, via a wireless mesh network based on Zigbee standards. The wireless site lighting control installs on top of a luminaire via an ANSI C136.41 compliance 7-pin twist-lock connector.
2. The wireless site lighting control shall be individually addressable via the wireless system management and can switch luminaires ON/OFF via an integrated high current relay, dim luminaires equipped with 0-10V dimming drivers or ballasts and has an input for an external occupancy sensor.
3. Specifications:
 - a. Power:
 - 1) Operating voltage 120V-347V
 - 2) Power consumption as no load: <1.0W
 - 3) Surge protection: 6kV, 6kA
 - b. Load Rating: 10A: Electronic driver/ballast, magnetic ballast, resistive load
 - c. Interface:
 - 1) Single dimming output that is 0-10V (IEC 60929 Annex E), DA-LI or DEXAL compatible.
 - 2) Sink/source 10 mA
 - 3) Sensor Input: Maximum 20 mA; minimum 18; nominal 19.5V
 - d. Software:
 - 1) Individual addressability
 - 2) Time schedule based control
 - 3) Daylight based control
 - 4) Astronomical schedule based control
 - 5) Occupancy based control
 - e. Power Metering
 - 1) V, I, P Energy
 - a) Accuracy is <2% from 0.5A to 10A load
 - b) Accuracy is <5% below 0.5A
 - f. Environmental
 - 1) Operational Temp: -40 deg. F to +150 deg. F (-40 deg. C to +65 deg. C)
 - 2) Relative humidity: 0% to 95%
 - 3) Ingress protection: IP66
 - g. Communication
 - 1) Wireless protocol: ZigBee
 - 2) Radio Frequency: 2.4 GHz
 - 3) Transmit power: 20 dBm
 - 4) Up to 1,000 ft. Line of sight between modules
 - h. Physical
 - 1) Base diameter: 3.31 in. (84 mm); height: 2.61 in. (66.4 mm)
 - 2) Weight: 0.44lbs (200g)
 - 3) Color: black
 - 4) Housing: UV stabilized PC
 - i. Regulatory
 - 1) UL/916/773 cULus listed
 - 2) Meets ASHRAE Standard 90.1 and CEC Title 24 requirements
 - 3) FCC Part 15/ICES-003

N. Wireless Manager

1. The wireless manager shall collect, process and distribute lighting control information to control modules over a wireless mesh network. Each wireless manager typical can control up to 100 nodes.
2. The wireless manager is the central intelligence point in the system for the wireless devices. It collects signal information from control modules, it then determines appropriate brightness levels or ON/OFF status for each fixture and zone.
3. Specifications:
 - a. Wireless Range: 100 ft. line of sign, 50 ft through standard walls
 - b. Wireless manager Network Port – Ethernet 1-/100BaseTx Cat. 5 RJ45 port
 - c. Dual PoE ports for daisy chain of up to 3 wireless managers
 - d. Status LED on front of unit
 - e. Configuration stored in non-volatile flash memory
 - f. Weights: 115g (4.06oz) wireless manager 40g (1.41 oz) ceiling mounted kit
 - g. Operating temperature range: 32 deg. F to 104 deg. F (0 deg. C to 40 deg. C)
 - h. AES 128-bit encryption for wireless communication
 - i. Dimensions: 2.81 in. W x 4.631 in. H x 0.78 D (71.37mm W x 117.6mm H x 19.81mm D)
 - j. Includes Polaris 3D software
 - k. cULus Listed
 - 1) Energy Management Equipment (UL 916)
 - l. Complies with the following electromagnetic requirements:
 - 1) EN 61000-4-2
 - 2) EN 610000-4-4
 - 3) EN 610000-4-5
 - m. FCC Part 15/ICES-003

O. System Field Devices (Input and Output Modules)

1. General: Input Modules provide a common interface to low voltage occupancy sensors and photo sensors while Output Modules provide a common interface to 0-10V Dimming, Fixed Output Ballasts and/or 0-10V LED Drivers and analog dimming devices such as incandescent low-voltage dimming modules. These modules automatically self-address and detect the type of devices they are connected to (i.e., photo sensor, occupancy sensor, 0-10V ballast, 0-10V LED drivers or incandescent dimming module) and establish two-way communication between the system Control Unit (CU) and themselves. These individually addressable modules enable each lighting component to be independently controlled and configured to best meet the needs of the facility.
 - a. Addressing: System Field Devices shall be individually addressable via Central Control Software.
 - b. System shall automatically address individual nodes during system commissioning thus eliminating the need to pre-address devices or record serial numbers during installation.
 - c. Modules shall at minimum meet the listed general, mechanical and environmental specifications set at below.
2. Air Gap Off
 - a. Definition: Air Gap Off shall refer to the physical disconnection of AC power to the ballast or driver when “OFF” is selected either automatically or manually, thus ensuring maximum energy savings by eliminating off-state phantom power losses

as well as ensuring that no potentially lethal high-voltage is present at the ballast or driver when the lights appear to be off (for life-safety reasons).

- b. Provisions: Provide an air-gap off relay for each control zone in the system. Where each fixture is to be controlled (dimmed and/or switched) independently, provide one relay per fixture. Where multiple fixtures are to be controlled (dimmed and/or switched), provide one relay per control zone, sized to handle both the inrush current as well as the maximum connected load, at the specified voltage.
3. General Specifications:
 - a. Shall supply 12VDC (up to 24VDC) to sensors.
 - b. Shall have 2 ports that accept 18 AWG, pre-fabricated, polarity independent quick connecting Class 2 communication bus that supplies 24 VDC.
 - c. Two models, one rated for regular indoor use and other for use in damp locations such as basements, cold storage areas. shall be available.
 - d. Memory: Retains all system settings in non-volatile memory.
 4. Mechanical Specifications:
 - a. Wiring: The System Field Device shall not require wiring connections to the System apart from pre-terminated, quick connecting 18 AWG, polarity independent quick connecting Class 2 communication bus.
 5. Environmental Specifications:
 - a. Operating Temperature Range: -40 deg C to +55 deg C.
 - b. Humidity: 0 percent to 100 percent RH condensing rated for damp locations 0 percent to 95 percent RH non-condensing rated for indoor locations.

P. Energy Control Unit

1. General: The Energy Control Unit (ECU) is a rack or wall mounted lighting control device that collects, processes and distributes lighting control information to System Field Devices and lighting controllers over a Class 2 communication bus. Each ECU has multiple Class 2 communication channels and can control a large quantity of nodes (sensors, lighting controllers, 0-10V Dimming, Fixed Output Ballasts and 0-10V LED Drivers.) per channel, per the manufacturers recommended maximum. The ECU is the central intelligence point for the area that it controls, collecting signal information from sensors, lighting controllers and personal control software and determining appropriate brightness levels or on/off status for each fixture or zone. Each ECU has an Ethernet connection for communication with a facility's or tenant's Local Area Network (LAN) to enable desktop personal control.
 - a. Shall interconnect with other ECUs and System Server Unit (SSU) using standard Ethernet connection that employs TCP/IP protocol.
 - b. Control units shall at minimum meet the mechanical, electrical, data, electromagnetic and environmental specifications listed below.
 - c. Mechanical Specifications:
 - d. Shall mount in a standard 1 inch rack (1U width), or alternatively where no rack is shown, via an individual wall mount.
2. Electrical Specifications:
 - a. Power Supply: 120V/60Hz/200W. Provide dedicated 120V receptacle fed from a dedicated normal power circuit; do not connect to a UPS or normal/emergency power source.

3. Data Specifications:
 - a. Shall have 8 ports that accept 18 AWG, pre-fabricated, polarity independent quick connecting Class 2 communication bus that supplies 24 VDC
 - b. Each ECU channel shall support up to 100 nodes or 800 nodes in total.
 - c. Each ECU shall have two Ethernet 10/100Base - Tx Cat 5 RJ45 ports that employs TCP/IP protocol:
 - 1) Lighting Control Network
 - 2) Tenant LAN Access Point
 - d. Shall have a status LED on front of unit.
 - e. Shall have configuration stored in non-volatile flash memory.
4. Shall comply or exceed the following electromagnetic requirements:
 - a. EN 61000-4-2
 - b. EN 61000-4-4
 - c. EN 61000-4-5
 - d. FCC Part 15/ICES-003
5. Environmental Specifications:
 - a. Operating Temperature Range: -20 deg C to +40 deg C.
 - b. Humidity: 0 percent to 95 percent RH non-condensing.

Q. System Server Unit

1. General: System Server Unit (SSU) shall host the lighting control system database for all the lighting control devices. Server shall have the ability to:
 - a. Remotely access a system in order to change system settings or configuration;
 - b. Analyze system performance or energy data or generate system report;
 - c. Record energy consumption with average sampling every 5 minutes for unlimited duration;
 - d. Host the web interface required for the web enabled Personal Control Software or web based Central Control Software;
 - e. Optionally can reside on a client server (virtual server) thus eliminating the need for dedicated physical hardware if desired;
 - f. Interconnect with ECUs over standard Ethernet connection that employs TCP/IP protocol;
2. Hardware based servers shall at minimum meet the specifications listed below:
 - a. Specifications:
 - 1) Mechanical Specifications:
 - a) Shall mount in a standard 19-inch rack (1U width), or alternatively where no rack is shown, via an individual wall mount.
 - b. Electrical Specifications:
 - 1) Power Supply: 120V/60Hz/200W. Provide dedicated 120V receptacle fed from a dedicated normal power circuit.
 - c. Regulatory:
 - 1) FCC (US only) Class A.
 - 2) DOC (Canada) Class A.
 - 3) UL 60950.
 - 4) CAN/CSA-C22.2 No. 60950.

R. Communication Wire

1. Wiring: 18 AWG, pre-fabricated, polarity independent quick connecting wiring. The system shall have the capability to use both Class 1 and Class 2 wiring. The maximum connected length of wiring shall be 2500 ft. per channel.
2. Field Bus: Integrates peripheral devices such as 0-10V ballasts and/or 0-10V LED drivers, occupancy sensors, photo sensors, relay-based controls, power packs and low voltage wall controls into a complete, networked programmable lighting control system. Provides power to photo sensors, PIR occupancy sensors and dual-technology occupancy sensors. Devices may be connected randomly on the network and special termination of each network channel is not required.
3. Field bus shall at minimum meet the specifications listed below:
 - a. Specifications:
 - 1) Class 2 communication bus.
 - 2) Prefabricated one ft., five ft., ten ft., 15 ft., 20 ft., 25 ft. and 50 ft. lengths.
 - 3) Daisy chain topology
 - 4) Prefabricated with 2-wire connectors.
 - 5) Flame rated jacket for plenum use NFPA 262 (UL: FT6, CSA: CMP).
 - 6) Power Supply: 12 VDC (up to 24 VDC) to sensors.

S. Conductors and Cables

1. Class 2 Control Cable: Multi-conductor cable with stranded-copper conductors not smaller than No. 18 AWG.

T. Lighting Control Panels

1. General
 - a. Addressing: All lighting control panels shall be individually addressable via Central Control Software.
 - b. Communication: All lighting control panels shall communicate via the same prefabricated, quick connecting low voltage wiring as all other devices.
 - c. Wiring: Relay control panels shall be interconnected on the same field bus as all other system components.

U. Lighting Control System Software

1. Personal Control Software: Enables individuals in a building to control lighting levels in their workspace from their own desktop PC. User can control the light level of each fixture in their workspace or can control all of the fixtures together as a group. Preset lighting scenes may be stored, recalled and modified. This software shall have the capability of acting as a “virtual occupancy sensor” for the system by detecting keyboard or mouse activity on each PC for incremental occupancy status data.
 - a. Technical Information:
 - 1) TCP/IP network traffic < 2kb/s.
2. Web based Personal Control Software: This feature allows individuals to control lighting levels in their workspace without the requirement for installation of software on client PCs. Individuals can access the interface through the web browser and perform individual fixture dimming control, on/off switching, modify and save preset lighting scenes.
3. Technical Information: Adobe Flash ® based user interface.

- a. System Requirements:
 - 1) Internet web browser with Flash® Player 8 or later.
 - 2) Internet/Intranet connection.
 - 3) SSU enabled and configured to host dynamic website.
 - 4) Network connection with access to a network-enabled CU.

4. Web based Central Control Software: Central control software application is used to commission, configure and manage the system. Every system parameter in a building (or campus of buildings) is configured for each individual user or space and baseline settings are established for each of the following (depending on the basis of design) system features:
 - a. Daylight harvesting.
 - b. Occupancy control.
 - c. Smart time scheduling.
 - d. Task tuning.
 - e. Personal control.
 - f. Load shedding.
 - 1) Software utilizes a web based interface that permits a user to easily navigate between zones, floors or different buildings and allows a user to zoom in or zoom out of specific areas of a building. Both 3-dimensional and 2-dimensional multi-floor views shall be available. System features such as creation of zone hierarchies, overlapping and support zone definitions, user access rights, timeout settings for occupancy sensors, calibration of light levels for daylight harvesting and the configuration of multiple time schedule profiles shall be available. A web based Graphical User Interface (GUI) application integral to the system will be used to develop a dynamic, real-time, point-and-click graphic of each floor plan with representation of all light fixtures, lighting controllers, sensors, and switches. A central system server will be provided to support system data base and enterprise control management.

5. System Requirements:
 - a. Software must be able to run on a Windows Operating systems (Windows XP or newer) and also on Apple Mac Intel PCs (Mac OS 10.4 or newer).
 - b. Must support all common browsers, i.e.,
 - 1) Internet Explorer 6.0 or later
 - 2) Mozilla Firefox 3.0 or later
 - 3) Safari
 - 4) Google Chrome
 - c. Network connection with access to network-enabled CUs.
 - d. Color gradient (“weather map” type) data view (see below for an example) shall be available to display the following criteria:
 - 1) Current energy consumption
 - 2) Current energy savings
 - 3) Current fixture brightness
 - 4) Current fixture status
 - 5) Current occupancy data
 - 6) Current load shedding status
 - 7) Other custom modes that may be specified elsewhere

V. Photo Sensor:

Photo sensors shall at minimum meet the specifications listed below:

1. General Specifications:
 - a. Shall be Class 2, low voltage.
 - b. Ambient light sensor designed to interface directly with the analog input of the Lighting Control System.
 - c. Sensor shall supply an analog signal to the ALCS proportional to the light measured.
 - d. Sensor output shall provide for zero or offset based signal.
 - e. Sensor shall be capable of a fully adjustable response in the range between 0 and 10,000 foot candles with a +/- 1 percent accuracy at 70 deg F.
 - f. Input: 10VDC.
 - g. Minimum Output: 0 VDC.
 - h. Maximum Output: 10 VDC.
 - i. Sensor housing shall be flame retardant and meet UL 94 HB standards.
 - j. Operating Temp: -10 deg C to 60 deg C.
 - k. The sensitivity adjustments shall be at sensor body, and outside of the sensor's viewing angle.
 - l. The sensor housing shall be flame retardant and meet UL 94HB standards
2. Interior:
 - a. Indoor sensors shall have a Fresnel lens, with a 60 degree cone of response. The indoor sensor range shall be between 0 and 750 FC.
3. Exterior:
 - a. Outdoor models shall have a hood over the aperture to shield the sensor from direct sunlight. The outdoor sensor circuitry shall be completely encased in an optically clear epoxy resin. Outdoor sensors shall mount to a standard threaded 1/2 in. conduit or fit a 1/2 in. knockout. The Outdoor sensor range shall be between 0 and 750 FC.
4. Atrium:
 - a. The Atrium sensors shall have a translucent dome with a 180 degree field of view. Atrium sensor shall mount to a standard treaded 1/2 in. conduit or fit a 1/2 in. knockout. Atrium sensor range shall be from 2 to 2,500 FC.
5. Skylight:
 - a. The Skylight sensors shall have a translucent dome with a 180 degree field of view. Skylight sensor shall mount to a standard treaded 1/2 in. conduit or fit a 1/2 in. Skylight sensor range shall be between 10 and 7,500 FC.

W. Occupancy Sensors:

1. Environmental:

Operating Temperature Range: 0°C to 40°C

 - a. Relative Humidity: 0 percent to 95 percent non-condensing
 - b. Ceiling Mount Occupancy/Vacancy Sensors
 - 1) Sensing mechanism:
 - 2) Dual technology (ultrasonic / passive infrared):
 - 3) Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
 - 4) Utilize an operating frequency of 32kHz or 40kHz that shall be crystal controlled to operate within plus or minus 0.005 percent tolerance.

- 5) Electrical: Rating: 12 VDC input voltage, up to 40 mA current draw.
- 6) Sensors shall turn off or reduce lighting automatically after reasonable time delay when a room or area is vacated by the last person to occupy the space
- 7) Sensor shall accommodate all conditions of space utilization and all irregular work hours and habits.
- 8) Sensors shall be UL listed.
- 9) Sensors shall be fully adaptive and adjust their sensitivity and timing to ensure optimal lighting control for any use of the space
- 10) Sensors shall have field adjustable controls for time delay and sensitivity to override any adaptive features. Sensor timeouts shall be configurable by System software.
- 11) Power failure memory:
- 12) Controls incorporate non-volatile memory. Should power be interrupted and subsequently restored, settings and learned parameters saved in protected memory shall not be lost.
- 13) Provide all necessary mounting hardware and instructions.
- 14) Sensors shall be Class 2 devices.
- 15) Indicate viewing directions on mounting bracket for all Ceiling mount sensors.
- 16) Provide customizable mask to block off unwanted viewing areas for all ceiling mounted sensors using infrared technology. Field prepare proper maskings for each space to eliminate unnecessary sensing beyond the space in which the sensor is located.
- 17) Provide an internal additional isolated relay with Normally Open, Normally Closed and Common outputs for use with HVAC control, Data Logging and other control options.

X. Power Packs

1. General:

- a. Power pack shall be a self-contained transformer and relay module.
- b. The internal relay shall control up to 20A for 120, 230, 277VAC or 347VAC ballast loads and 120VAC incandescent loads.
- c. Power packs shall provide a 24 VDC, 150 mA output.
- d. Power packs shall be capable of parallel wiring without regard to AC phases on primary.
- e. Power pack can be used as a standalone, low voltage switch, or can be wired to sensor for auto control.
- f. Construction shall be high impact, UL rated plastic case
- g. Power pack shall be UL/CUL Listed, FCC Certified, UL 2043 plenum rated and meets ASHRAE 90.1 requirements
- h. To ensure quality and reliability, power and auxiliary relay packs shall be manufactured by an ISO 9002 certified manufacturing facility and shall have a defect rate of less than 1/3 of 1 percent.
- i. Shall at minimum meet the following environmental specifications:
 - 1) Operating Temperature Range: 0 deg. C to 40 deg. C
 - 2) Relative Humidity: 0 percent to 95 percent non-condensing

Y. Examination

1. Site Verification: Verify that wiring conditions, which have been previously installed under other sections or at a previous time, are acceptable for product installation in accordance with manufacturer's instructions.
2. Inspection: Inspect all material included in this contract prior to installation. Manufacturer shall be notified of unacceptable material prior to installation.

Z. Installation

1. The Electrical Sub-contractor, as part of the work of this section, shall coordinate, receive, mount, connect, and place into operation all equipment. The Electrical Sub-contractor shall furnish all conduit, wire, connectors, hardware, and other incidental items necessary for properly functioning lighting control as described herein and shown on the plans (including but not limited to System Field Devices, 0-10V dimming ballasts, fixed output ballasts, 0-10V LED drivers and communication wire). The Electrical Sub-contractor shall maintain performance criteria stated by manufacturer without defects, damage, or failure.
2. Power: The contractor shall test that all branch load circuits are operational before connecting loads to sensor system load terminals, and then de-energize all circuits before installation.
3. Related Product Installation: Refer to other sections listed in Related Sections for related products' installation.

AA. Sensor Installation

1. Adjust sensitivity to cover area installed
2. Set time delay on occupancy sensors that are connected to the lighting control system to the minimum. Time delays shall be controlled via Central Control Software.
3. Sensor shall be powered through Input Module. No external power packs shall be used for powering sensors.
4. Install occupancy sensors on vibration free stable surface.
5. Install atrium and skylight light sensor facing toward window or skylight.
6. Install interior light sensor in ceiling facing the floor.

BB. Wiring Installation

1. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 3/4 inch.
2. Wiring within Enclosures: Comply with NEC & CEC. Separate power-limited and non power-limited conductors according to conductor manufacturer's written instructions.
3. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

CC. Software Installation

1. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current site licenses for software.
2. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
3. Perform the following field tests and inspections with the assistance of a factory-authorized service representative:

- a. Operational Test: After installing lighting controllers and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Lighting control devices will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports.

DD. Commissioning Requirements

1. Commissioning: The manufacturer shall supply factory trained representatives for a minimum of 24 hours to commission the lighting control system. Manufacturer shall start up all lighting control equipment and verify that it meets the requirements of this specification.
2. Training: As part of the standard commissioning process, the manufacturer shall train the owner's representatives in the operation of the system to a maximum of 4 hours per building. Manufacturer shall also provide owner's representatives with system operating manuals together with a system training video.
3. Technical Support: The manufacturer shall supply 24/7 technical telephone support to the client. If the manufacturer does not provide 24/7 support, they must provide a list of contacts (names and cell phone numbers) in the event of a system failure during non-business hours.
4. Replacement components: The manufacturer shall be able to ship replacement parts within 24 hours for any component that fails during the warranty period.
5. Extended Service Coverage: Maintenance agreements shall be available from the manufacturer to provide service for the system both during and after the warranty period.
6. Requests for commissioning shall be at least two weeks prior to date desired for commissioning.
7. Electrical Sub-contractor shall perform functional testing under the guidance of commissioning agent and in accordance with factory specified guidelines.
8. Factory appointed personnel shall provide commissioning services for the lighting control system.
 - a. Verify proper communication over control wires.
 - b. Map addresses of occupancy sensors (via Input Modules), light level sensors (via Input Modules), lighting controllers to control units and system server.
 - c. Map all system data to appropriate BACnet points and assist BMS sub-sub-contractor in programming all points into the BMS system and verifying their proper functionality.
 - d. Verify communication to control units and system server.
 - e. Configure occupancy sensors, light level sensors, lighting controllers and other contacts to suit design specifications.
 - f. Configure and program lighting control sequences as described on contract documents.
 - g. Demonstrate to Owner and Engineer proper operation of all areas the system is installed.

EE. Testing

1. Upon completion of all line, load and interconnection wiring, and after all fixtures are installed and lamped, a qualified factory representative shall completely configure and test the system.
2. At the time of checkout and testing, the owner's representative shall be thoroughly instructed in the proper operation of the system.

FF. Demonstration and Training:

1. Engage a factory-authorized service representative to train Owner's maintenance personnel and building supervisors to adjust, operate, utilize, troubleshoot, conduct software installation, and maintain lighting controls and software training for PC-based control systems. Provide up to eight hours of on-site training with audio and video recorded in (2) four hour sessions. Provide a hard copy of manuals, instructional videos, and recorded training session(s) on CD or DVD.

2.20 LADDER TRAY/WIREWAYS

- A. Provide ladder tray where indicated on drawings. Ladder tray shall be as manufactured by b-line, "ladder type", or equal. Provide all hangers required.
- B. Wireway:
 1. This specification covers NEMA type 1 wireway used to house and protect communication cable. The wireway system shall consist of wireway and appropriate fittings to complete the installation per the electrical drawings.
 2. Metal wireway (NEMA type 1) is to be utilized in dry interior locations only as covered in article 362 part a of the national electrical code, as adopted by the national fire protection association and as approved by the American National Standards Institute. The wiremold c" or "sp" series is listed by underwriters' laboratories under file no. E137690 guide zoyx.
 3. The wireway system specified herein shall be the "c" or "sp" system as manufactured by the wiremold company. Systems of other manufacturers may be considered equal if, in the opinion, and the written approval of the engineer, they meet all the performance standards specified herein.
 4. The wireway and all system components must be UL Listed in full compliance with their standard ul870, "electrical wireways, auxiliary gutters and associated fittings". It shall be manufactured from 16-gauge cold rolled steel, finished in ASA 61 gray powder coat paint. All sizes larger than 6 in. x 6 in. shall be manufactured from 14-gauge cold rolled steel, finished in ASA 61 gray powder coat paint. A factory installed divider shall be available to separate power and low voltage wiring housed in the same wireway sections.
 5. A full complement of fittings for the raceway shall be available including, but not limited to, 45 deg. and 90 deg. flat, vertical inside and outside elbows, tee and cross fittings, couplings for joining sections of wireway, reducers, hangers, end blanks, a field installed divider and all other components necessary to make the system workable. The fittings shall have an ASA 61 gray powder coat paint finish to match the wireway.
 6. Prior to and during installation, refer to system layout drawing containing all elements of the system. Installer shall comply with detailed manufacturer's instruction sheets which accompany system components as well as complete system instruction sheets, whichever is applicable.
 7. All wireway systems shall be mechanically continuous and connected to all electrical boxes and cabinets, in accordance with manufacturer's installation sheets.

8. All connections shall be checked to make sure they are correctly tightened and to insure that all wireway shall be electrically continuous and bonded in accordance with the national electric code for proper grounding.
9. All wireway systems shall be installed complete. Work shall include fastening all wireway and appropriate fittings to install a complete wireway system as indicated on the electrical and/or communication drawings and in the applicable specifications

2.21 SEALS

A. Water Tight Seals

1. Conduits entering from the exterior or below grade shall have water tight fittings on the outside and on the inside of the conduit.
 - a. Fittings on the outside of the conduit shall be O-Z Gedney type FSK or equal. Provide type WSK if penetration is within two feet of the high water table. Provide grounding attachment.
 - b. Fittings on the inside of the conduit shall be O-Z Gedney type CSBI or equal. Provide type CSBG if penetration is within two feet of the high water table. Provide a blank fitting to seal spare or empty conduits.
 - c. O-Z Gedney type CSM or equal fitting may be used when sealing within a sleeve or cored hole.
2. Submit on seals to be used.

B. Environmental Seals

1. Provide seals on raceways exposed to widely different temperatures, as in refrigerating or cold storage areas. Install seal to prevent circulation of air from warmer to colder sections through the raceway.

C. Hazardous Area Seals

1. Provide explosion proof seals as required by the Electric Code.
 - a. Explosion-proof exhaust fans.

D. Smoke and Fire Stopping Seals

1. Provide a seal around raceways or cables penetrating full height walls (slab to slab), floors or ventilation or air handling ducts so that the spread of fire or products of combustion shall not be substantially increased.
2. Penetrations through fire-resistant-rated walls, partitions, floors or ceilings shall be firestopped using approved methods and NRTL listed products to maintain the fire resistance rating.
3. Fire stopping in sleeves or in areas that may require the addition or modification of installed cables or raceways shall be a soft, pliable, non-hardening fire stop putty. Putty shall be water resistant and intumescent. Provide for all sleeves and raceways.
4. Firestopping in locations not likely to require frequent modification shall be NRTL listed putty, caulk or mortar to meet the required fire resistant rating.
5. Box penetrations into a fire rated wall or shaft shall have a fire stopping pad installed on the back of the box.

6. Firestopping of cable trays or busways through walls shall be within a non-hardening putty or with seal bags.
7. Firestopping materials shall be NRTL listed to UL 1479 (ASTM E814). Installation methods shall conform to a UL firestopping system. Submit specifications and installation drawings for the type of material to be used. Firestopping materials shall be as manufactured by 3M, International Protective Coatings Corp., RayChem or approved equal.

2.22 LIGHTNING PROTECTION SYSTEM

A. General:

1. Provide all labor, material, equipment, and services required for the complete lightning protection system in accordance with NFPA 780, UL96A and applicable contract drawings for the Building. System shall receive UL Master Label. This section is responsible for providing a design for an approved "UL Master Label System" in accordance with the drawings and specifications.

B. The following items of work are specifically included in, but not necessarily limited to the work of this section without limiting the generality implied by the Specifications.

1. Air terminals.
2. Copper cable roof conductors.
3. Down conductor.
4. Ground grid installation.

C. Manufacturer shall provide seven complete sets of shop drawings for review, showing location of air terminals, conductors, installation procedures and details, and detailed manufacturer's data sheets on all components, accessories, and miscellaneous equipment to be used in this installation.

D. Description of System:

1. The contractor shall provide a complete installation of equipment to comprise a system for protection against damage by lightning.
2. The system, including air terminals, conductors, and complementary parts, shall be installed so that completed work is unobtrusive and does not detract from the building appearance.
3. The work shall comply with all applicable federal, state, municipal laws, ordinances, and regulations.

E. Standards of Quality:

1. All materials shall be the product of a manufacturer regularly engaged in the production of lightning protection equipment.
2. All material shall be manufactured by Thompson Lightning Protection, Harger, East Coast Lightning Equipment, Heary Bros. or equal.

F. Service, Testing and Guarantee:

1. Installation of equipment shall be done under direct supervision of the equipment manufacturer's factory representative. A master labeled system is to be provided.
2. The completed lightning protection systems shall be fully tested in the presence of the Architect to demonstrate continuity of all conductors. A written test report shall be submitted.
3. The ground grid resistance shall be measured and a written statement submitted to the architect. Grid resistance shall be 5 ohms or less.

G. Products:

1. Air Terminals:
 - a. Complete assembly consisting of chrome plated air terminal with attachment mechanisms.
2. Conductors:
 - a. Copper conductors shall be 28 strands of #13 gauge, net weight 420 pounds per 1000 ft., minimum.
3. Ground Rods:
 - a. Ground rods shall be copperweld, $\frac{3}{4}$ in. minimum diameter, 10 feet minimum length.
4. Connectors, Fitting, Fasteners and Hardware:
 - a. Provide all connectors, fittings, fasteners, hardware, clamps, guards, lugs, etc., as required to connect, interconnect and install all parts of the system.
 - b. All shall be fabricated from copper metal and be approved for use intended.
 - c. All connections between dissimilar metals shall have connectors approved for this type of application.

H. Installation:

1. Installation shall be accomplished in a professional manner by qualified personnel regularly engaged in and experienced in this type of work.
2. All work installed within the building shall be concealed.
3. All work installed in accessible locations shall be properly guarded and protected.
4. All material shall be installed in a manner to prevent electrolytic action under the presence of moisture.
5. All roof, wall or other building penetrations shall be made in a manner to prevent the ingress of water or moisture. Roof penetrations shall be furnished and installed by Roofing Contractor.
6. PVC sleeves shall be provided where conductors pass through all floors.
7. Installation shall be accomplished in a manner to eliminate possibility of displacement and subsequent maintenance.
8. All connections shall be mechanically and electrically sound and all bonding surfaces shall be cleaned and brightened just prior to attachment.
9. All excavating, backfilling and tamping earthwork as required by General Trades Contractor.
10. Install down conductors concealed within wall.
11. Cables on flat roof areas may be run exposed. Adhesive type fasteners shall be spaced at 3 ft. – 0 in. maximum. Adhesive used shall be compatible with roofing materials. Coordinate with approved shop drawings.

12. Ground rods shall be driven to full depth in soil undisturbed by building excavation and are not to be driven into excavation backfill area.
13. Provide connection between grid and water service.
14. Provide grid resistance of 5 ohms maximum.
15. Top of ground rods shall be installed at least 2 ft. – 0 in. below finished grade.

I. Master Label:

1. Submit factory certified tests.
2. Submit guarantee for installation and range of lightning protection.

2.23 ELECTRICITY MUTLI-METERING

A. COORDINATION

1. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. WARRANTY

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

C. PRODUCTS

1. MULTIPLE CHECK METERING SYSTEM

- a. Provide a system of check meters consisting of Multiple Meter Unit Cabinets equal to E-MON D-MON MMU Series. Multiple Meter Cabinets shall consist of 8, 16 and 24 meters as indicated on Plans. Each meter shall meet the following criteria:
 - 1) Meter shall be fully electronic with 4-line by 20-character backlit LCD display showing kwh, kW consumption and demand (with peak date and time), power factor per phase, real-time load in kW, Amps per phase and Volts per phase. The meters must be capable of reporting hourly, daily, monthly and annual energy use.
 - 2) Meter shall utilize 0-2 volt AC output current sensors to allow paralleling and/or mounting up to 500 feet from the meter. Sensor shall be of split-core configuration to allow installation without disconnecting cabling. Sensors shall be available from 100 amp to 1200 amp. Sensors shall be optionally available to solid-core configuration (100 & 200 amp.)
 - 3) Meter shall be field programmable for meter date/time and ID code for communication options.
 - 4) Meter shall provide installation diagnostics on display.
 - 5) Meter shall be enclosed in MMU NEMA 1 enclosure (standard) with padlocking hasp & mounting flanges for indoor/outdoor installation (stand alone) with one 1 1/16 in. KO on bottom of enclosure.
 - 6) Meter shall be UL/CUL Listed to latest applicable standards for safety.
 - 7) Meter shall meet or exceed NSI C12.20 accuracy standards.
 - 8) Meter shall provide non-volatile memory to maintain reading during power outages.

- 9) Meter shall store interval data or kWh and kVARh for up to 72 days in first-in first-out formal. (Standard firmware).
- 10) Meter shall be capable of daisy-chain or star connection using RS-485 communications in combinations of Class 3200s, 3400s, 5000s, IDR-8s, IDR-16s not to exceed 52 devices. Cabling shall be available terminal block (3-conductor), 18-22AWG, up to 4,000 cable feet total. Class 1000 meters may be used for single phase loads.
- 11) Meter shall be provided with the following communication protocols:
 - a) Requires third-party EMS/BMS system supplied by others to store for a minimum of 36 months and allow for data to be remotely accessible per LEED requirements.
 1. BACnet MS/TP (Replace EZ7 in model with BAC when ordering)
 2. Modbus RTU Communications (Replace EZ7 in model with RTU when ordering)
2. Multiple Meter Unit Cabinets shall be prewired complete with voltage feeds. Clearly label all meter with load served.
3. Acceptable Manufacturers:
 - a. E-Mon D-Mon
 - b. National Meter Industries
 - c. Square D
 - d. Or Equal

D. Training

1. Provide 4 hours of owner training.

- E. The smoke control system shall be programmed so that a self-test is automatically conducted by the fire alarm/smoke control system at a pre-determined time each week. The self-test must provide a printed report indicating the pass/fail of each equipment and overall system pass/fail status.

2.24 UNDERGROUND DUCTBANKS

- A. General: Furnish and install the ductbanks as herein specified and as shown on drawings.

B. Division of Work:

1. The General Trades Contractor shall be responsible for the work and material required for the following:
 - a. Excavation
 - b. Backfill
 - c. Installation of handholes/manholes, precast foundations.
 - d. Brick or concrete collars to bring handhole frames and covers up to grade. Installation of frames and collars which are to be furnished by the Electrical Contractor.
 - e. Concrete Encasement
2. All other material, equipment, and labor required for the complete ductbank shall be furnished and installed by the Electrical Contractor under this Section, including the following:

- a. Service raceways.
- b. Grounding material.
- c. Ductbank warning tape.
- d. Furnish pre-cast handholes/manholes, precast foundations.
- e. Conduit spacers.

C. Materials:

- 1. Conduit: UL listed, schedule 40 PVC in accordance with NEMA standard TC-2.
- 2. See BASIC MATERIALS SECTION.
- 3. Conduit Supports (duct system): Shall be molded plastic with interlocking lugs and skeletonized structure, minimum separation 3 in.
- 4. Tags: Non-ferrous metal or fibre, ¼ in. high letters.
- 5. Warning tape shall be yellow polyethylene 4 mil thick, 6 in. wide terratape, similar to REEF Industries, Houston, Texas and shall be installed above all ductbanks both high and low tension.

D. Duct System:

- 1. The duct system shall consist of Schedule 40 PVC conduit except where otherwise specified. The size and number of conduits shall be as indicated on the drawings. Provide a pull wire in each conduit.
- 2. The entire length between handholes and end of ductbank shall be excavated and graded before any conduit is laid.
- 3. The ductbank shall be set on undisturbed earth.
- 4. The conduit shall be installed so that top is a minimum of 36 in. below finished grade unless otherwise indicated, and shall be laid to a minimum grade of 4 in. for each 100 feet of length. Duct system shall drain to manholes/handholes.
- 5. Changes in direction shall be made by long sweep bends, minimum radius 25 feet except that at the end of a run, within 10 feet of termination. Manufactured ends may be used having a minimum radius of 36 inches.
- 6. Conduit base and intermediate spacers shall be installed a maximum of 5 feet on centers. Spacers shall not be placed one above the other, but shall be staggered a minimum of 6 in.
- 7. All conduit joints shall be made watertight by means of a sealing compound before the coupling is installed. Joints in conduit shall be staggered, minimum space between joints in adjacent conduit shall be 6 in..
- 8. When the required number of conduits have been installed, securely tie the assembly together at distances not exceeding 7 feet. Tie shall consist of three (3) turns of No. 18 iron wire. Separate ties required for low tension and high tension conduit runs.
- 9. Duct envelope shall be vibrated to eliminate voids.
- 10. Ductbanks shall not be covered until the conduit installation has been observed by the utility company and Architect.
- 11. Warning tape shall be installed during backfilling and shall be placed approximately 12 in. above the conduits.
- 12. After the installation is completed, each conduit shall be cleaned and identified. A standard flexible mandrel and a stiff bristle brush shall be pulled through each conduit. The mandrel shall not be less than 12 in. long and the diameter approximately 1/4 in. less than the conduit.

2.25 VARIABLE FREQUENCY DRIVES (VFD'S)

- A. The variable frequency drives (VFD's) shall be solid state, with a Pulse Width Modulated (PWM) output waveform (VVI, six-step, and current source drives are not acceptable). The VFD package as specified herein shall be enclosed in a NEMA 1 enclosure, completely assembled and tested by the manufacturer. The VFD shall employ a full wave rectifier (to prevent input line notching), DC Line Reactor, capacitors, and Insulated Gate Bipolar Transistors (IGBT's) as the output switching device (SCR's, GTO's and Darlington transistors are not acceptable). The drive efficiency shall be 97 percent or better at full speed and full load. Fundamental power factor shall be 0.98 at all speeds and loads.
- B. Specifications at 480 volts:
 - 1. Input VAC +/-10 percent (capable of operation to 550 VAC), 3 phase, 48-63Hz. Output 0 - Input Voltage, 3 phase, 0 to 500 Hz for drives up to 75 HP; 0 to 120 Hz for drives over 75 HP. Operation above 60 Hz. shall require programming changes to prevent inadvertent high speed operation. Environmental operating conditions: 0 to 40 C @ 3 klz switching frequency, 0 to 3300 feet above sea level, less than 95 percent humidity, non-condensing. Units shall be UL, CUL and CA approved.
- C. All VFD's shall have the following standard features:
 - 1. All VFD's shall have the same customer interface, including digital display, keypad and customer connections; regardless of horsepower rating. The keypad is to be used for local control, for stepping through the displays and menus.
 - 2. The VFD shall give the user the option of either (1) displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last reference revised, or (4) cause a Warning to be issued, if the input reference (4-20mA or 2-10V) is lost; as selected by the user. The VFD shall provide a programmable relay output for customer use to indicate the loss of reference condition.
 - 3. The VFD's shall utilize plain English digital display (code numbers and letters are not acceptable). The digital display shall be a 40-character (2 line X 20 characters/line) LCD display. The LCD shall be backlit to provide easy viewing in any angle. All set-up parameters, indications, faults, warnings and other information must be displayed in words to allow the user to understand what is being displayed without the use of a manual or cross-reference table.
 - 4. The VFD's shall utilize pre-programmed application macro's specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time.
 - 5. The VFD shall have the ability to automatically restart after an overcurrent, overvoltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between reset attempts shall be programmable. If the time between reset attempts is greater than zero, the time remaining until reset occurs shall count down on the display to warn an operator that a restart will occur.
 - 6. The VFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).
 - 7. The VFD shall be equipped with an automatic extended power loss ride-through circuit which will utilize the inertia of the load to keep the drive powered. Minimum power loss

- ride-through shall be one-cycle, based on full load and not inertia. Removing power from the motor is not an acceptable method of increasing power loss ride-through.
- 8. The customer terminal strip shall be isolated from the line ground.
- 9. Prewired 3-position Hand-Off-Auto switch and speed potentiometer. When in "Hand", the VFD will be started, and the speed will be controlled from the speed potentiometer. When in "Off", the VFD will be stopped. When in "Auto", the VFD will start via an external contact closure, and its speed will be controlled via an external speed reference.
- 10. The drive shall employ three current limit circuits to provide trip free operation.
- 11. The Slow Current Regulation limit circuit shall be adjustable to 125 percent (minimum) of the VFD's variable torque current rating. This adjustment shall be made via the keypad, and shall be displayed in actual amps, and not as percent of full load. The Rapid Current Regulation limit shall be adjustable to 170 percent (minimum) of the VFD's variable torque current rating. The Current Switch-off limit shall be fixed at 255 percent (minimum, instantaneous) of the VFD's variable torque current rating. The overload rating of the drive shall be 110 percent of its variable torque current rating for 1 minute every 10 minutes, and 140 percent of its variable torque current rating for 2 seconds every 15 seconds, input line fuses standard in the drive enclosure. VFD shall have a DC Line Reactor to reduce the harmonics to the power line and to increase the fundamental power factor.
- 12. The VFD shall be optimized for a 4 kHz carrier frequency to reduce motor noise and provide high system efficiency. The carrier frequency shall be adjustable by the start-up engineer in ACH 501 units. The VFD shall have a manual speed potentiometer in addition to using the keypad as a means of controlling speed manually.

D. All VFD's to have the following adjustments:

- 1. Five programmable critical frequency lockout ranges to prevent the VFD from continuously operating at an unstable speed.
- 2. PI Setpoint controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the VFD, using the microprocessor in the VFD for the closed loop control.
- 3. Two programmable analog inputs shall accept a current or voltage signal for speed reference, or for reference and actual (feedback) signals for PI controller. Analog inputs shall include a filter; programmable from 0.01 to 10 seconds to remove any oscillation in the input signal. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0-20 MA and 0-10 Volts. Additionally, the reference must be able to be scaled so that maximum reference can represent a frequency less than 60 Hz, without lowering the drive maximum frequency below 60 Hz.
- 4. Six programmable digital inputs for maximum flexibility in interfacing with external devices. One digital input is to be utilized as a customer safety connection point for fire, freeze, and smoke interlocks (Enable). Upon remote, customer reset (reclosure of interlock), drive is to resume normal operation.

E. The following operating information displays shall be standard on the VFD digital display. The display shall be in complete English words (alpha-numeric codes are not acceptable):

Output Frequency
 Motor Speed (RPM, percent or Engineering units)
 Motor Current
 Calculated Motor Torque
 Calculated Motor Power
 DC Bus Voltage

Output Voltage
Heatsink Temperature
Analog Input Values
Keypad Reference Values
Elapsed Time Meter
kWh meter

F. Speed Command Input shall be via:

1. Keypad.
2. Two Analog inputs, each capable of accepting a 0-20mA, 4-20mA, 0-10V, 2-10V signal. Input shall be isolated from ground, and programmable via the keypad for different uses.
3. Floating point input shall accept a three-wire input from a Dwyer photohelic (or equivalent type) instrument.

G. Accessories to be furnished and mounted by the drive manufacturer.

1. Customer Interlock Terminal Strip-provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external interlocks and start/stop contacts shall remain fully functional whether the drive is in hand, Auto or Bypass.
2. All wires to be individually numbered at both ends for ease of troubleshooting.
3. Door interlocked thermal magnetic circuit breaker which will disconnect all input power from the drive and all internally mounted options. The disconnect handle shall be thru-the-door type, and be padlockable in the "Off" position.
4. Manual transfer to line power via contactors. Include motor thermal overload and fuse or circuit breaker protection while in bypass operation. A three position selector switch to control the bypass contactor and the drive output contactor is to be mounted on the enclosure door. When in the "Normal" mode, the bypass contactor is open and the drive output contactor is closed. In the "Test" position both contactors are open, and in the "Bypass" position, the drive output contactor is open, and the bypass contactor is closed. The drive output contactor shall also open when a stop command is given, isolating the motor from the drive. Start/stop signals and safety interlocks will work in drive and bypass modes.
5. Pilot lights or LED's shall be provided for indication of "Normal" operation, "Bypass" operation, and "External Fault". All pilot lights shall be push-to-test type.
6. Service contactor (drive input contactor) which provides the ability to service the drive (electrically isolate the drive while in bypass operation without having to remove power from the motor). The service contactor shall open when the drive is switched to bypass, and also be controlled by a switch which is mounted inside the drive enclosure so that its access is limited to service personnel only.
7. A class 20 bimetallic thermal motor overload relay shall be provided to protect the motor in bypass.

H. Compliance to IEEE - 519

1. The VFD manufacturer shall provide calculations specified to this installation showing that the Total harmonic Distortion for the VFD's, reflected into the electrical distribution system is limited to the level defined by IEEE - 519 (latest edition) for general systems. Harmonic analysis shall be included with VFD submittal for approval by the engineer.

2. The VFD manufacturer shall conduct on site harmonic measurements before and after startup of the VFD's. Results of the measurements, showing harmonic contribution of the VFD's, shall be provided to the engineer one month after start up.
 3. Three phase A. C. input, 3 percent line reactors (externally mounted ahead of diode bridge) shall be provided as a minimum, with all VFD's. The line reactors are to provide attenuation of line side voltage transients, thus preventing overload trips or other unnecessary V.F.D. shutdown, and provide a reduction in harmonic distortion.
 4. Line reactors shall have the following requirements:
 - a. Three (3) percent line impedance (line side of drive).
 - b. 150 percent continuous current rating for one minute.
 - c. Saturation rating no less than 2.5 times the continuous current rating.
 - d. U.L. recognized.
- I. General: Install variable frequency drives where indicated, in accordance with manufacturer's published installation instructions, complying with recognized practices to ensure that variable frequency drives comply with requirements and serve intended purposes.
- J. Access: Provide access space around control panels for service as indicated, but in no case less than that recommended by manufacturer.
- K. Support: Install drive control panels on walls where indicated on drawings. Provide necessary Unistrut and structural steel to provide adequate support as required by manufacturer.
- L. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- M. Start-Up
1. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.
- N. Adjusting and Cleaning:
1. Alignment: Check compatibility of control panel to motor and where necessary, adjust frequency and provide necessary filters to assure noise free operation of motors. Verify response from control panel to motor to assure turn down ratio specified and that static pressure signals are being received and that drives are controlling as specified and within recommended tolerances by manufacturer. Provide start-up report prepared by manufacturers representative to assure operation is as specified.
 2. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- O. Acceptable Manufacturers:
1. ABB
 2. Allen – Bradley

3. Siemens
4. Square D
5. Or equal

2.26 LEVEL 2 AC DUAL ELECTRIC VEHICLE CHARGING EQUIPMENT (EVSE)

- A. Scope: Furnish and install Level 2 with RFID AC Dual Electric Vehicle Charging equipment as specified herein and as shown on the contract drawings.
- B. References: The electric vehicle supply equipment (EVSE) and all components shall be designed, manufactured and tested in accordance with the latest version of the following standards (unless otherwise noted):
 1. SAE J1772, Electric Vehicle Conductive Charge Coupler
 2. SAE J2836 , Use Cases for Communication Between Plug-in Vehicles and the Utility Grid
 3. SAE J2847, Communication between Plug-in Vehicles and the Utility Grid
 4. SAE J2931, Digital Communications for Plug-in Electric Vehicles
 5. National Electric Code Article 625, Electric Vehicle Charging System
 6. UL 2231, Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits
 7. UL 2594, Electric Vehicle Supply Equipment
 8. UL 1998, Software in Programmable Components
 9. CSA C22.2 No. 107.1, General Use Power Supplies
 10. FCC Part 15, Class B
- C. Submittals – for Review/Approval
 1. The following information shall be submitted to the Engineer:
 - a. Product data sheets
 - b. Installation Manuals
- D. Submittals – for construction
 1. The following information shall be submitted for record purposes:
 - a. Final as-built drawings
 - b. Wiring diagrams
 - c. Installation information including equipment anchorage provisions
- E. Qualifications
 1. The manufacturer shall have been self-manufacturing EVSE or similar transportation electrification equipment for a minimum of three years. The manufacturer shall also have been in manufacturing for a minimum of five (5) years.
- F. Delivery, Storage and Handling
 1. EVSE being stored prior to installation shall be stored so as to maintain the equipment in a clean and dry condition as required by the manufacturer's instructions, in accordance with manufacturer's instructions (1) copy of these instructions shall be included with the equipment at time of shipment.

G. Operation and Maintenance Manuals

1. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly.

H. Warranty

1. The manufacturer warrants equipment to be free from defects in materials and workmanship for 1 year from date of substantial completion.

I. Manufacturers

1. Chargepoint
2. Or equal

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Basis of Design is Chargepoint CT4021.

J. Construction

1. Provide a third party recognized AC, Level 2 charging station, quantities and current ratings as shown on drawings.
2. Physical Specifications
 - a. Enclosure Construction and Finish
 - 1) Enclosure shall be manufactured from aluminum or other corrosion resistant material
 - 2) Enclosure shall consist of a coat of thermosetting, polyester powder paint applied electrostatically with a metallic finish.
 - b. Enclosure Mounting
 - 1) Pedestal Mount with Dual SAE J1772 connectors
 - c. Cable Length
 - 1) 25 feet
 - d. Connector and Cable Management
 - 1) The EVSE shall incorporate a cord management system or method to minimize the potential for cable entanglement, user injury or connector damage from lying on the ground and comply with NEC articles 625 as it applies to cord management systems.
 - 2) The EVSE shall include a dock for inserting the SAE J1772 connector when not in use.
 - 3) The EVSE connector and cable assembly shall be field replaceable.
 - e. The EVSE shall include a removable device panel to allow for field retrofits and replacement of optional equipment.

K. Environmental

1. Operating Temperature
 - a. -22 F (-30 C) to 104 F (40 C)
2. Surge Withstand

- a. 6kV at 3000A
3. Humidity
 - a. 90 percent relative humidity, non-condensing
 - b. Corrosion Resistance
 - c. The enclosure coating shall have a corrosion resistance of 600 hours to 5 percent salt spray.
4. The printed circuit boards (PCB's) integral to the EVSE shall be conformal coated.
5. User Interface
 - a. The station's display shall be simple, with universal symbols accompanying text to allow easy understanding and use of the EVSE.
 - b. The EVSE shall include the following status indicators:
 - 1) Power
 - 2) Charging
 - 3) Charging Complete
 - 4) Remotely Controlled
 - 5) Temporary Fault
 - 6) Service
 - c. The EVSE shall include the following:
 - 1) Reset Pushbutton
6. Protection
 - a. The EVSE shall provide integral overcurrent protection at 5 percent over the nameplate rating.
 - b. The EVSE shall provide integral ground fault interruption of 20mA per UL 2231.
 - c. The EVSE shall incorporate an automatic ground fault detection feature at the beginning of each plug session.
 - d. The EVSE shall incorporate a manual ground fault test feature.
 - 1) The EVSE shall include a DIP switch enabled Automatic Reset feature to allow the station to reset after a temporary fault without user interaction.
 - e. The EVSE shall include a DIP switch enabled Soft Start feature to allow for the ramp up of current to the Available Line Current or Nameplate Current Rating of EVSE.
 - f. The EVSE shall include a Cold-Load Pickup feature to allow for randomized restart on power failure and/or delay before charging resumes after a power failure.
7. Input / Output
 - a. The EVSE shall include a normally closed (NC) dry contact permissive run input.
8. Communications and Data Collection
 - a. The EVSE shall be open architecture with native Modbus RTU and RS-232 Serial communications.
 - b. The EVSE shall allow for curtailment of the maximum current output through Modbus communications.
 - c. The EVSE shall be capable of Master / End Device configurations through a Modbus RTU daisy chain topology.
9. Required Accessories
 - a. Systems Integration Enabled
 - 1) Communications for Open Charge Point Protocol networking

- 2) Authentication and Payment Authorization
 - a) Swipe Credit Card Reader for time based payments
- 3) Local area network 2.4Ghz Wi-Fi(802.11b/g/n)
- 4) Wide area network 3G GSM, 3G CDMA

L. Factory Testing

1. Each EVSE shall undergo factory testing of all operational and protective features prior to shipment.

M. Installation

1. The Electrical SubContractor shall install all equipment per the manufacturer's recommendations and contract drawings.

N. All necessary hardware to secure the assembly in place shall be provided by the Electrical SubContractor.

O. Training

1. Provide four (4) hours of owner training with manufacturer's representative present.

P. Service plan

1. Provide a 5 year service plan for each station.

PART 3- EXECUTION

3.01 WORK COORDINATION AND JOB OPERATIONS

- A. Equipment shall not be installed in congested and possible problem areas without first coordinating installation of same with other trades. Relocate electrical equipment installed in congested or problem areas should it interfere with the proper installation of equipment to be installed by other trades.
- B. Particular attention shall be directed to coordination of lighting fixtures and other electrically operated equipment requiring access which is to be installed in ceiling areas. Coordinate with other trades, the elevations of equipment in hung ceiling areas to insure adequate space for installation of recessed fixtures before said equipment is installed. Conflicts in mounting heights and clearances above hung ceilings for installation of recessed lighting fixtures or other electrically operated equipment requiring access shall be brought to the attention of Architect for a decision prior to equipment installation.
- C. Furnish to General Trades Contractor and other subcontractors information relative to portions of electrical installation that will affect other trades sufficiently in advance so that they may plan their work and installation.
- D. Obtain from other trades information relative to electrical work which he, the Electrical Subcontractor, is to execute in conjunction with installation of other trades' equipment.

- E. Lighting fixtures in mechanical spaces or utility/ storage rooms shall only be installed after all mechanical equipment is in place.

3.02 PLANS AND SPECIFICATIONS

A. Plans:

- 1. Drawings showing layout of electrical systems indicate approximate location of raceways, outlets, and apparatus. Runs of feeders and branch circuits are schematic and are not intended to show exact routing. Final determination as to routing shall be governed by structural conditions and as indicated on the approved coordination drawings.

B. Specifications:

- 1. Specifications supplement drawings and provide specifics pertaining to methods and material to be used.

3.03 IDENTIFICATION

A. Equipment shall be marked for ease of identification as follows:

- 1. Provide screw-on nameplates on switchboards, panelboards, F.A. terminal cabinets, starters, and disconnect switches. Nameplates to be of black phenolic with white engraving. For starters and disconnect switches lettering shall be minimum of ¼ in. high. Nameplates on panelboards shall have the following information.
 - a. Line 1 - Panel designation in ½ in. high letters.
 - b. Line 2 - Utilization voltage in 3/8 in. high letters.
 - c. Line 3 - Distribution source "Fed from ¼ in. high letters.
- 2. Neatly typed directory cards listing circuit designations shall be fastened inside the cover of panelboards. Spare circuits shall be penciled.
- 3. Provide Signage on all rooms that contain Fire alarm control equipment within it. Where a Fire alarm control panel is located within a separate room provide permanent signage that reads " FIRE ALARM CONTROL PANEL INSIDE" with minimum 7 in. high by 10 in. width with 2-inch high block letters a 0.5 in. letter stroke - white letters on a contrasting red background. The sign shall be permanently attached, at normal eye level to the door leading to the fire alarm control panel(s).
- 4. Color coding schedules. If there is more than a single system voltage, different voltages shall have separate color codes, as previously specified. A copy of the color code schedule shall be affixed to each secondary switchboard and distribution panel and shall be of the phenolic nameplate type as previously specified. A typewritten color code schedule shall also be affixed, under plastic, inside each panelboard door.
- 5. Outlet boxes both concealed and exposed shall be identified as to panel origination and circuit number by means of fibre pen on the inside of coverplate.
- 6. Special system outlet boxes concealed above hung ceilings shall be identified as to system by spray painting during roughing. The following systems shall be identified.
 - a. Fire Alarm - red.
 - b. Normal/Emergency - yellow.
 - c. Security - blue.
 - d. Sound - green.

7. Wiring device plates on devices connected to normal-emergency circuits shall be red in color.
8. All conductors in boxes larger than standard outlet boxes, in all wireways, and trench headers, shall be grouped logically and be identified.
9. Grounding conductors and neutrals shall be labeled in panels, and wireways, as to circuits associated with.
10. Emergency system wiring shall comply with 700.10(A).
11. Power and raceway identification:
 - a. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
 - b. Colors for Raceways Carrying Circuits at 600 V or Less:
 - c. Black letters on an orange field.
 - d. Legend: Indicate voltage and system or service type (Power, Lighting, Emergency, Control).
 - e. Colors for Raceways Carrying Circuits at More Than 600 V:
 - f. Black letters on an orange field.
 - g. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high letters.
 - h. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
 - i. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- wide black stripes on 10-inch centers diagonally over orange background that extends full length of raceway. Stop stripes at legends.
 - j. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
 - k. Write-On Tags: Polyester tag, with corrosion-resistant grommet and cable tie for attachment to conductor or cable. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
12. Armored metal clad cable identification:
 - a. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
 - b. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.
13. Power and Control Cable identification:
 - a. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
 - b. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
 - c. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
 - d. Write-On Tags: Polyester tag, with corrosion-resistant grommet and cable tie for attachment to conductor or cable. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

- e. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
14. Conductor Identification materials:
- a. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
 - b. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
 - c. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
 - d. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
 - e. Write-On Tags: Polyester tag, with corrosion-resistant grommet and cable tie for attachment to conductor or cable. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
15. Underground warning tape:
- a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines but not less than 4 mils thick and 6 inches wide.
 - b. Printing on tape shall be permanent and shall not be damaged by direct-burial service.
 - c. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
 - d. Color and Printing:
 - 1) Comply with ANSI Z535.1 through ANSI Z535.5.
 - 2) Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
 - 3) Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.
16. Warning labels and signs:
- a. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
 - b. Baked-Enamel Warning Signs:
 - c. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. Nominal size, 7 by 10 inches.
 - d. Metal-Backed, Butyrate Warning Signs:
 - e. Weather-resistant signs, non-fading, preprinted, cellulose-acetate butyrate signs with galvanized-steel backing; and with colors, legend, and size required for application. Nominal size 10 by 14 inches.
 - f. Safety signs shall warn of potential electrical hazard and shall include, but are not limited to, the following legends:
 - g. Multiple power source warning.
 - h. Workspace clearance warning.
 - i. Potential electric arc flash hazard.

17. Equipment identification labels:
 - a. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.
 - b. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.
 - c. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.
18. Cable ties:
 - a. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
 - b. Minimum Width: 3/16 inch.
 - c. Color: Black except where used for color-coding.
 - d. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
 - e. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking. UL 94 Flame Rated.
19. Verify identity of each item before installing identification products. Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and required by code.
20. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
21. Apply identification devices to surfaces that require finish after completing finish work.
22. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
23. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
24. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
25. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
26. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
27. Outdoors: UV-stabilized nylon.
28. In Spaces Handling Environmental Air: Plenum rated.
29. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
30. Renovation Projects: For alterations and additions to existing facilities, use existing identification system. Where systems have not been standardized, use the identifying and marking system specified in this standard.
31. Distribution Equipment: Identify major components of the distribution system (such as circuit breakers, switches, transformers, switchboards, panelboards, motor control centers)

with nameplates. Nameplates on disconnect switches and control stations shall identify the equipment served.

32. Identification Schedule:

- a. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for service, feeder, and branch circuits more than 30A and 120V to ground: Identify with self-adhesive vinyl label applied at 10-foot maximum intervals.
- b. Power-Circuit Conductor Identification, 600 V or Less: Identify conductors in the panels, pull and junction boxes, manholes, handholes.
 - 1) Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors for ungrounded service, feeder and branch-circuit conductors as specified in Division 26 Section "Low-Voltage Power Conductors".
 - a) Factory applied continuous color coding for conductors No.8 AWG and smaller.
 - b) Field-applied, color coding conductor tape: For conductors No.6 AWG and larger. Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made.
 - 2) Lighting and Receptacle Outlet Boxes: Identify with the panel and circuit number.
- c. Power-Circuit Conductor Identification, above 600 V: For conductors in the vaults, pull and junction boxes, manholes and handholes, use write-on tags.
- d. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- e. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
- f. Terminal Blocks: Attach numbered nameplates to terminal blocks which require identification numbers; use the designations shown on the wiring diagrams. Install nameplate at the top of vertically mounted terminal blocks and at the end of horizontally mounted terminal blocks. Indicate the individual terminal point designation shown on the wiring diagrams.
- g. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
- h. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in the finished spaces.
- i. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Apply warning, caution, and instruction signs where required by the referenced Electrical code, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install self-adhesive warning labels or baked-enamel warning signs with approved legend where instructions or explanations are needed for system or equipment operation. Install metal-backed, butyrate warning signs for outdoor items.
- j. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch high letters for emergency instructions at equipment used for power transfer, load shedding and other emergency operations.
- k. Safety sign for the switchboards and panelboards: Provide a sign to warn qualified persons of potential electric arc flash hazard.

- l. All electrical distribution equipment and mechanical/plumbing/fire protection equipment fed from the electrical distribution system shall contain in addition to the identification requirements listed in this section shall be labelled where they are fed from. For example Distribution panel 4DP1A is fed from MSB-1A, its label shall be “4DP1A fed from MSB-1A” submit full labeling scheme for review and approval.
- m. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to the disconnect switches and protection equipment, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
 - 1) Labeling Instructions:
 - a) Indoor Equipment: Self-adhesive, laminated acrylic or melamine label.
 - b) Outdoor Equipment: Engraved, laminated acrylic.
 - c) Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
 - 2) Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be engraved laminated acrylic. Panelboard directories shall identify the load name and location (i.e. AHU-1, Room #, FCU-1, Room #).

3.04 PROTECTION AND CLEANUP

A. Protection:

- 1. Materials and equipment shall be suitably stored and protected from weather.
- 2. During progress of work, pipe and equipment openings shall be temporarily closed so as to prevent obstruction and damage.
- 3. Be responsible for maintenance and protection of material and equipment until final acceptance.

B. Cleanup:

- 1. Keep job site free from accumulation of waste material and rubbish. Remove all rubbish, construction equipment, and surplus materials from site and leave premises in a clean condition.
- 2. At completion, equipment with factory finished surfaces shall be cleaned and damaged spots touched up with the same type paint applied at factory.
- 3. Particular attention is called to Section 110-12(c) of the NEC, which requires that internal parts of electrical equipment not be contaminated by construction operations.

3.05 PORTABLE OR DETACHABLE PARTS

- A. Retain possession of and be responsible for spare parts, portable and detachable parts, and other removable portions of installation including fuses, keys, locks, blocking clips, inserts, lamps, instructions, drawings, and other devices or materials that are relative to and necessary for proper

operation and maintenance of the system until final acceptance, at which time such parts shall be installed or turned over to the Owner, as the case may be.

3.06 SAFETY PRECAUTIONS

- A. Provide proper guards, signage, and other necessary construction required for prevention of accidents and to insure safety of life and property. Remove any temporary safety precautions at completion.

3.07 MOUNTING HEIGHTS

- A. All electrical equipment shall be mounted at the following heights unless noted or detailed otherwise on drawings. Notes on architectural drawings shall supersede those noted below or detailed on the electrical drawings. If mounting height of an electrical component is questionable, obtain clarification from Architect before installation.
 - 1. Duplex convenience outlets, microphone outlets, and telephone outlets - 18 inches.
 - 2. Light switches, pushbutton stations, HOA switches, and all other toggle or control switches for the operation of heating, ventilating, and air conditioning, plumbing, and general service - 48 inches.
 - 3. Clock outlets - 84 inches.
 - 4. Fire alarm pull stations - 48 inches.
 - 5. Fire alarm audio visual signals - 80 inches or 6 inches below ceiling, whichever is lower.
 - 6. Panelboards for lighting, power, telephone, and other auxiliary systems - 78 in. to top.
 - 7. Equipment located in lobbies shall be located as detailed on architectural drawings or as directed by Architect.
 - 8. All receptacles, light switches, fire alarm signals, and clocks sharing a common location shall be symmetrically arranged.
 - 9. Exterior and interior wall brackets shall be as detailed on architectural drawings or as directed by Architect.
 - 10. All controllers, power supplies, panels and electrical equipment with exception of junction boxes and pull boxes shall be installed in electric rooms.
- B. Mounting heights given are from finished floor to centerline. In the case of a raised floor, surface of raised floor is the finished floor.

3.08 WORKMANSHIP AND INSTALLATION METHODS

- A. Work shall be installed in first-class manner consistent with best current trade practices. Equipment shall be securely installed plumb and/or level. Flush-mounted outlet boxes shall have front edge flush with finished wall surface. No electrical equipment shall be supported by work of other trades. Cable systems shall be supported and not draped over ducts and piping or laid on ceiling suspension members. Lighting fixtures shall be installed to agree with Architects reflected ceiling plans.
- B. Supports:
 - 1. Support work in accordance with best industry practice and by use of standard fittings.

2. In general, walls and partitions will not be suitable for supporting weight of panelboards, dry type transformers and the like. Provide supporting frames or racks extending from floor slab to structure above.
3. Provide supporting frames or racks for equipment, intended for vertical surface mounting in free standing position where no walls exist.
4. Supporting frames or racks shall be of standard angle, standard channel or specialty support system steel members, rigidly bolted or welded together and adequately braced to form a substantial structure. Racks shall be of ample size to assure a workmanlike arrangement of equipment.
5. Provide 3/4 in. thick painted plywood mounting surfaces in all electric and telephone areas and for all equipment on free standing racks. All plywood shall be fire retardant and painted both sides and edges with two coats of white paint.
6. No work for exposed installations in damp locations shall be mounted directly on any building surface. In such locations, flat bar members or spacers shall be used to create a minimum of 1/4 in. air space between building surfaces and work.
7. Nothing (including outlet, pull and junction boxes and fittings) shall depend on electric raceways or cables for support. All outlet, pull, and junction boxes shall be independently supported.
8. Nothing shall rest on, or depend for support on, suspended ceiling or its mounting members.
9. Support surface or pendant mounted lighting fixtures:
 - a. From outlet box by means of an interposed metal strap, where weight is less than five pounds.
 - b. From outlet box by means of a hickey or other direct threaded connection, where weight is from five to fifty pounds.
 - c. Directly from structural slab, deck or framing member, where weight exceeds fifty pounds.
 - d. Pendant lighting fixtures shall be supported by threaded rods in non-public areas and by manufacturer's standard tube hangers with swivel aligner and canopy in public areas. Provide non-standard pendant lengths where required to mount fixtures at elevations either called for on drawings or as shown in architectural elevations.
10. Support recessed lighting fixtures directly from structural slabs, decks or framing members, by means of jack chain or air craft cable, one at each end of fixture at opposite corners.
11. Where support members must of necessity penetrate air ducts, provide airtight sealing provisions which allow for a relative movement between the support members and the duct walls.
12. Provide channel sills or skids for leveling and support of all floor mounted electrical equipment.
13. Where permitted loading is exceeded by direct application of electrical equipment to a slab or deck, provide proper dunnage to distribute the weight in a safe manner.
14. Support metallic raceways by either running within steel frame or hung from the building frame. Anything hung from building frame shall be attached with metallic fasteners.

C. Fastenings:

1. Fasten electric work to building structure in accordance with the best industry practice.
2. Where weight applied to attachment points is 100 pounds or less, fasten to building elements of:
 - a. Wood -- with wood screws.

- b. Concrete and solid masonry -- with bolts and expansion shields.
 - c. Hollow construction -- with toggle bolts.
 - d. Solid metal -- with machine screws in tapped holes or with welded studs.
- 3. Where weight applied to attachment points exceeds 100 pounds, fasten as follows:
 - a. At field poured concrete slabs, provide inserts with 18 in. minimum length slip-through steel rods, set transverse to reinforcing steel.
 - b. Where building is steel framed, utilize suitable auxiliary channel or angle iron bridging between structural steel elements to establish fastening points. Bridging members shall be suitably welded or clamped to building steel. Provide threaded rods or bolts to attach to bridging members.
 - 4. Floor mounted equipment shall not be held in place solely by its own dead weight. Provide floor anchor fastenings. Floor mounted equipment over 72 inches in height shall also be braced to nearest wall or overhead structural elements.
 - 5. For items which are shown as being mounted at locations where fastenings to the building construction element above is not possible, provide suitable auxiliary channel or angle iron bridging to building structural elements.
 - 6. Fastenings for metallic raceways using the fastening as support shall be of the metallic type. Fastenings to hold raceways or cables in place may be via tywraps.

D. General Raceway Installation:

- 1. Install the various types of raceways in permitted locations as previously specified. All raceways shall be run concealed. Consult Architect for instruction for raceways which must be exposed in public spaces.
- 2. Raceways for normal emergency or emergency only wiring cannot contain other conductors.
- 3. Raceways shall be properly aligned, grouped, and supported in accordance with code. Exposed raceways shall be installed at right angles to or parallel with structural members. Concealed raceways may take most direct route between outlets.
- 4. Raceways run on trapeze hangers shall be secured to the trapeze.
- 5. Raceways shall be continuous and shall enter and be secured to all boxes in such a manner that each system shall be electrically continuous from service to all outlets. Provide grounding bushings and bonding jumpers where raceways attach to painted enclosures or terminate below equipment.
- 6. Where raceways enter boxes, cabinets, tap boxes, other than those having threaded hubs, a standard locknut shall be used on the outside and locknut and bushing on the inside.
- 7. Where raceways terminate below equipment and there is no direct metal to metal continuity, provide grounding bushings on raceways and interconnect with equipment grounding conductor.
- 8. All empty raceways shall be provided with a pull wire.
- 9. All raceway sleeves, stub-ups, or stub-outs, where not connected to a box or cabinet, shall be terminated with a bushing.
- 10. All raceway joints shall be made up tight and no running threads will be permitted.
- 11. Where raceways are cut, the inside edge shall be reamed smooth to prevent injury to conductors.
- 12. All vertical raceways passing through floor slabs shall be supported.
- 13. Raceways shall not be installed in concrete slabs above grade or below waterproofed slabs.

14. Electric raceways and/or sleeves passing through floors or walls shall be of such size and in such location as not to impair strength of construction. Where raceways alter structural strength or the installation is questionable, the structural engineer shall be contacted for approval.
15. Raceways shall not run directly above or below heat producing apparatus such as boilers, nor shall raceways run parallel within 6 inches of heated pipes. Raceways crossing heated pipes shall maintain at least a 1 inch space from them.
16. Raceways shall be installed in such a manner as to prevent collection of trapped condensates, and all runs shall be arranged to drain.
17. Raceways passing between refrigerated and non-refrigerated spaces and those penetrating enclosures with air movement shall be provided with seals.
18. Raceways feeding fire and jockey pumps shall be rigid metal conduit either run below slab or inside 2 hour rated enclosure. Final connections to motors shall be liquidtight flexible conduit.
19. Where two alternate wiring methods interconnect such as EMT to flexible metal conduit, an outlet box shall be provided.
20. All empty raceways entering building and all sleeves or core drilled openings through floors shall be sealed.
21. Each exterior raceway or assembly in a duct bank shall be provided with continuous warning tape installed 12 inches above raceway or duct bank.
22. Underground rigid non-metallic raceways where allowed and run as a duct bank encased in concrete shall be installed with plastic spacers to ensure a separation of 3 inches between raceways. Top of duct banks shall be 30 inches below grade, unless otherwise detailed.
23. Elbows and extensions of rigid non-metallic raceway systems which penetrate slabs shall be rigid or intermediate metal conduit.
24. Raceways used for transformer connections shall be flexible type and shall contain a grounding conductor.
25. Raceways entering building through foundation wall into a basement area shall be provided with wall entrance seals or with other acceptable waterproofing method.
26. Underground non-metallic raceways shall be fully surrounded by a selected backfill to prevent more than the desired deflection and, in power raceways is needed to provide room for heat dissipation and good compaction of backfill. Separation Between Direct-Buried, Non-encased Ducts: 3 inches minimum for like services, and 12 inches minimum between power and signal ducts, unless shown otherwise on the drawings. Raceways formation for non-encased ducts shall be built up layer by layer. After each layer is placed, the selected backfill shall be placed over it to the specified depth. This fill should be spread evenly and compacted to provide continuous support for the next tier of raceways. Any temporary spacers used should be removed from each layer of raceway as soon as backfill is completed in that layer. A maximum of 9 conduits shall be grouped in the same trench unless otherwise noted on the drawings.
27. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
28. Run conduit concealed in finished areas above suspended ceilings, in wall spaces. Exposed conduit runs in finished areas require Architect's approval. Properly group conduit runs. Install conduit parallel to walls, structure and ceilings, and support with proper hangers and clamps. Running conduits at the bottom of structural members in exposed conditions is not allowed. Check door swings before installing back boxes for switches and receptacles.
29. Where conduit passes through a building expansion joint, use weatherproof, telescopic type expansion fittings which permit at least 4 inches of movement.

30. Form bends in conduit by means of a conduit bending machine or by an approved hickey. To fasten conduit to outlet boxes, cabinets, use locknuts and insulated throat bushings of compatible material.
31. Cut conduit ends square, thread conduit, and ream to remove burrs and sharp edges. Field threads shall be of the same type and have the same effective length as factory cut threads. Turns, wherever required in exposed conduit runs, shall be made by the use of factory-made bends, or field-made bends that meet the requirements of this Section and Electric Code. In the event of a multiplicity of conduits making the same turn, a steel junction box with a removable steel cover may be used. Offsets and bends for changes in elevation of exposed conduit runs shall be made at walls or beams and not in open spaces between walls or beams. Rout conduits required to avoid interfere with the operation or maintenance of equipment.
32. Plug or cap conduit ends as soon as conduit is installed, to prevent entrance of moisture or other debris during construction. Do not pull wire into any conduit until the conduit system is complete.
33. Drawings, in relation to the routing of conduits, are diagrammatic. Except where additional conduits may be required to avoid derating of branch circuits, elsewhere within this Section, the number and size of conduits and wire shall be furnished and installed as indicated by the drawings. Coordinate routing of conduits in the field with the building structure. Run conduit in straight lines parallel and perpendicular to walls, beams, and columns and with right angle bends and threaded conduit fittings. Maintain 12 inches clearance between conduit and surface with temperatures exceeding 104 degrees F.
34. Conduits passing through floors, walls and beams shall be of such size, number, and in such locations so as not to impair the strength of the construction.
35. Rout raceways in ceiling spaces in an orderly and organized manner, and to eliminate or minimize the number of junction boxes required. Support and secure conduits by means of rods, clamps and other conduit support devices approved by the Architect. Do not use wire to support conduits.
36. Where rigid metal conduit is threaded in the field, use a standard conduit cutting die providing 3/4 inch taper per foot.
37. Conduit and EMT runs shall be mechanically and electrically continuous from service entrance to outlets. Secure conduit to cabinet, junction box, pull box or outlet box with locknut outside and bushing inside, or with liquid-tight, threaded, self-locking, cold-weld wedge adapter. Locknuts and bushings or self-locking adapters will not be required where conduits are screwed into tapped connections. Before installing conductions, protect vertical conduit runs that terminate in bottoms of wall boxes or cabinets from entrance of foreign material.
38. Size rigid steel conduit, EMT and flexible metallic conduit required by the referenced Electrical Code, except as otherwise specified or shown on the drawings. Check raceway sizes to determine that equipment grounding conductor fits in same raceway with phase and neutral conductors to meet Massachusetts Electrical Code percentage of fill requirements.
39. Where conduit is secured rigidly on opposite sides of building expansion joints, and where runs of exposed conduit are long and subject to stress, provide expansion fittings capable of safely deflecting and expanding to twice the distance of structural movement. Provide separate external copper bonding jumper secured with grounding straps on each end of fitting.
40. Install a pull or junction box every 100 feet of straight conduit run, and wherever there is an equivalent of four 90 degree elbows or a total of 360 degree bend. Install no more than

the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

41. Install sealing fittings at following points, and elsewhere as shown:
42. Where conduits enter or leave hazardous areas equipped with explosion proof lighting fixtures, switches, receptacles, and other electrical devices.
43. Where conduits pass from warm to cold locations.
44. Pull cords: In each empty raceway, provide nylon fishing line having tensile strength not less than 200 lbs, or provide No. 14 AWG steel wire. Label each end of each line or wire with a securely attached tag which indicates the location of the other end.
45. Liquid-tight type flexible conduits installed in the air-handling plenum space shall be with a plenum- rated outer jacket.
46. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

E. General Outlet Box Installation:

1. Boxes shall be set flush with finish surface and provided with proper type extension rings or plaster covers. Thru the wall boxes are not permitted. Check device or fixture to be mounted to box to ensure box orientation is proper.
2. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operation.
3. Remove knockouts as needed and plug unused openings.
4. Where required for horizontal and vertical alignment of boxes in stud partitions, bar hangers spanning two studs shall be used. Device boxes for insertion type receptacles shall be provided with far side box supports where there are less than two entering nonflexible raceways and where bar hangers are not provided.
5. Boxes flush mounted in fire rated partitions and on opposite sides of the partition shall be separated by a distance of 24 inches in accordance with UL listing for the box.
6. Locations of outlets indicated on drawings are approximate. For items exposed to view, refer to architectural drawings and coordinate locations with masonry joints, panel joints, ceiling grids, structural members.
7. In case of conflict with standard mounting heights and device alignment, consult Architect prior to roughing.
8. Check all door swings on architectural drawings to ensure lighting switches are installed on strike side of door.
9. The right to make any reasonable change in location of outlets prior to roughing is reserved by Architect. Reasonable change shall be interpreted as movement within 10 ft. of location shown.
10. Obtain dimensioned plan from Architect for floor outlets.
11. Outlet boxes for use where surface metal raceways are allowed shall be of a type specifically designed to be used with such surface metal raceway systems.

F. Conductor Installation:

1. No conductors shall be pulled into individual raceways until such raceway system is complete and free of debris. No harmful lubricants shall be used to ease pulling.
2. All conductors shall be wired so that grounded conductor is unbroken; switches in all cases being connected in ungrounded conductor.

3. Connections throughout the entire job shall be made with solderless type devices of approved design satisfactory to Inspector of Wires.
4. All taps and splices shall be insulated equal to that of conductor insulation.
5. All conductors of each feeder in pull boxes shall be grouped, tied together, supported, and identified.
6. All conductors in panelboards and other wiring enclosures shall be neatly formed and grouped.
7. All conductors of emergency only and/or normal/emergency shall be run in separate raceway systems to final outlet box.
8. Provide support for conductors in vertical raceways in accordance with Article 300-19.
9. Strip insulation from conductors with approved tools and only of sufficient length for proper termination. Cutting of conductor stranding is unacceptable.
10. Taps from paralleled conductors shall be of a type which tap each conductor, such as ILSCO PTA series.
11. Grounding conductors are to be identified as to associated power circuits.

G. Type MC Cable Installation:

1. Where cable is permitted under the products section, the installation of same shall be done in accordance with code and the following:
 - a. Cable shall be supported in accordance with code. Tie wire is not an acceptable means of support. Horizontally run cable supports such as Caddy WMX-6, and clamps on vertical runs such as Caddy CJ6 shall be used. Where cables are supported by the structure and only need securing in place, then ty-raps will also be acceptable. Ty-raps are not acceptable as a means of support. All fittings, hangers, and clamps for support and termination of cables shall be of types specifically designed for use with cable, i.e., romex connectors not acceptable.
 - b. Armor of cable shall be removed with rotary cutter device equal to roto-split by Seatek Co., not with hacksaw.
 - c. Use split insuliner sleeves at terminations.
 - d. Any cable system used in conjunction with isolated ground circuits shall have both an isolated ground conductor and an equipment ground conductor.

H. Stranded Conductor Installation:

1. If Contractor selects stranded conductors for # 10 AWG and smaller, terminate such conductors as follows:
 - a. No stranded conductor may be terminated under a screwhead. Provide insulated terminal lugs for all screw connections equal to Thomas & Betts STA-KON type RC with forked tongue and turned up toes. Installation of lugs shall be done with compression tool such as T&B WT-145C which prevents opening of tool until full compression action is completed.
 - b. Backwired wiring devices shall be of clamp type; screw tightened. Force fit connections not allowed.
2. Stranded conductors will not be allowed for fire alarm work.

I. Accessibility:

1. Electrical equipment requiring service or manual operation shall be accessible.

2. Work switches for equipment within accessible hung ceiling spaces, such as fan powered terminal boxes, shall be located at terminal box, and so located so as to be accessible.

J. Vibration Elimination:

1. All equipment connections to rotating equipment or equipment capable of vibration shall be made up by flexible raceways.

K. Wiring Device Gaskets:

1. Provide wiring device gaskets at coverplates where device is mounted in wall separating conditioned and non-conditioned spaces.

3.09 FEEDER CIRCUITS

- A. Provide feeders as called for on the drawings.
- B. Feeders shall be defined as any circuit originating from the distribution panels.
- C. All feeder conductors shall be continuous from origin to panel or equipment termination without splicing.
- D. All feeders shall be conductors pulled into raceways. Cable systems are not allowed for feeders unless specifically indicated.

3.10 BRANCH CIRCUITS

- A. Provide all branch circuit wiring and outlets for a complete and operating system. The system shall consist of insulated conductors connected to the panelboards and run in raceways or as cable systems if permitted under products section, as required to the final outlet and shall include outlet boxes, supports, fittings, receptacles, plates, fuses, etc.
- B. Physical arrangement of branch circuit wiring shall correspond to circuit numbering on drawings. Combining of circuits and raceways will be allowed up to a 3 phase, 4 wire circuit in a single raceway, unless shared neutrals are not allowed by other sections of this Division, or are indicated as separate neutrals on the drawings. Any combination of homeruns such as this, however, shall be indicated on record drawings. When a common grounded conductor is used for more than one circuit, the arrangement shall be such that a receptacle, fixture, or other device may be removed or disconnected without disconnecting the grounded conductor for other circuits. Ground fault circuit breakers and isolated ground outlets shall be wired with separate neutrals and separate grounding conductors per circuit. A consistent phase orientation shall be adhered to throughout project at terminations.
- C. Circuits feeding three phase equipment shall not be combined into common raceways, unless specifically indicated.
- D. All wiring in panelboards and cabinets shall be neatly formed and grouped.

3.11 FIREPROOFING AND WATERPROOFING

- A. Fireproof and waterproof all openings in slabs and walls.

3.12 CUTTING AND PATCHING

- A. Openings through new wall surfaces will be provided by General Conditions if Electrical contractor gives suitable notice as erection of surface proceeds. If suitable notice is not given, Electrical contractor shall then be responsible for cost of corrective work required.
- B. Patching will be provided by the trade responsible for the surface to be patched.

3.13 ELEVATOR COORDINATION

- A. Elevator Electrical Work:
 - 1. Several items pertaining to elevator electrical system shall be provided by Electrical Subcontractor as follows:
 - a. Power source to elevator machine room including fused disconnect switch and wiring between disconnect switch and controller for each elevator.
 - b. Power source to elevator machine room including fused disconnect switch (120 volt) for elevator signal system and cab light for each cab.
 - c. Light, switch, and GFCI receptacle in each pit.
 - d. Light, switch, and GFCI receptacle in machine room.
 - e. Junction box in machine room with five control modules from fire alarm system for elevator recall to prevent cab opening on a fire floor.
 - f. Junction box in machine room for cab telephone with one 1 in. conduit with (2) CAT 6 telephone cables to main telephone demarcation backboard terminate analog lines to telephone service.
 - g. Power to automatic damper in hoist way penthouse louver.
 - h. Power wiring to elevator sump pump.

3.14 MECHANICAL SYSTEM COORDINATION

- A. The Mechanical System contractor will be providing various items of mechanical services equipment and control apparatus. In general, Electrical contractor shall connect up power wiring to this equipment.
- B. The Mechanical and Electrical contractor shall closely coordinate their respective portions of work.
- C. If, due to local regulations, electric heating equipment furnished by the mechanical systems subcontractor is required to be installed by licensed electricians in order to allow connection by Electrical contractor's licensed electricians, it will then be Mechanical contractor's responsibility to engage and pay for services of such licensed electricians.
- D. Power wiring to be provided by Electrical contractor is the line voltage power supply wiring. Control wiring is responsibility of Mechanical System contractor unless specifically indicated on

electrical drawings, or in this Division of the specifications. Temperature Control contractor shall refer to electrical drawings for location of all magnetic starters.

- E. 120-volt control wiring source to temperature control panel is the responsibility of Electrical contractor.

3.15 DISTRIBUTION EQUIPMENT TESTING

- A. All panelboards, individual motor starters, main distribution panel, motor controls, feeder conductors, and emergency systems shall be tested in accordance with the following. In general, all tests shall be done in accordance with the 1995 Acceptance Testing Specifications of the International Electrical Testing Association.
- B. The Testing Subcontractor may be an independent contractor or a manufacturer of the equipment, which is to be tested.
- C. Test report forms, delineating tests to be made, and method of recording same shall be submitted prior to commencing work. Test reports when submitted shall include interpretation of results and recommendation for any corrective work required.
- D. Main Distribution Panel:
 - 1. Visual Inspection:
 - a. Check for foreign material within bus enclosure.
 - b. Check for missing hardware.
 - c. Inspect entire assemblies for transit damage or factory defects.
 - d. Check for all bus dimensions and bracing per specifications.
 - e. Check ratings of current transformers and potential transformers.
 - f. Check ratings of all protective relays per drawings.
 - 2. Physical Inspection:
 - a. Torque all bus hardware to proper tension.
 - b. Circuit breaker interlocks all work properly.
 - c. All doors and hinged panels open and close properly.
 - d. Relay blocking removed from all control and protective relays.
 - e. All circuit breakers operate, close and trip mechanically.
 - f. Torque all feeder conductors to terminal manufacturers' recommendations.
 - 3. Electrical Testing:
 - a. Breakers operated electrically trip and close from local and remote positions.
 - b. All circuit breakers calibrated to manufacturer's respective time current curves as specified.
 - 1) Long time pick-up amps.
 - 2) Long time delay tripping at 300 percent of current setting.
 - 3) Resets okay at 80 percent of pick-up value.
 - 4) Short time pick-up current.
 - 5) Short time delay trip time at 105 percent of setting.
 - 6) Instantaneous minimum pick-up current.
 - c. All protective relays calibrated to manufacturer's characteristic time curves for pick-up, drop-out, instantaneous and time delay.

- d. All instruments calibrated for accuracy.
- e. Protective relay schemes to be electrically tested by primary injection of current through current transformers and the tripping of associated circuit breakers.
- f. Insulation resistance tests made on all circuit breakers, line to load breaker open, line to ground breaker closed, 3 poses tested individually. Switchgear bus to be tested phase to phase and phase to ground with Megohmmeter type instrument. Relays also to be insulation resistance tested.

E. Magnetic Starters:

- 1. Visual inspection to determine:
 - a. Shipping damage.
 - b. Proper bussing and contactor sizes.
 - c. Correct overload relay heater ratings. Any incorrectly sized overloads shall be replaced by the contractor who originally provided same.
- 2. Electrical Testing:
 - a. Electrical operation of control relays, timing relay, and contactor coils.
 - b. Insulation resistance test on all current carrying bus to ground and between phases.
 - c. Calibration check of overload heater to ascertain tripping point and time delay at 300 percent of heater rating.

F. Conductors:

- 1. All secondary service conductors and all feeder conductors from switchboards and distribution panels shall be tested.
- 2. Visual and mechanical inspection
 - a. Conductors to be inspected for physical damage and proper connection and sizing in accordance with single line diagram.
 - b. Conductor connections shall be torque tested to manufacturer's recommended values.
- 3. Electrical Tests:
 - a. Perform insulation resistance test on each conductor with respect to ground and adjacent conductor.
 - b. Perform continuity test to insure proper conductor connection.

G. Emergency Systems:

- 1. Engine Generator - Prior to the emergency generator test specified under the emergency generator specification, the testing contractor shall perform the following:
 - a. Visual and Mechanical Inspection:
 - 1) Inspect for physical damage.
 - 2) Compare nameplate rating and connection with specifications and single line diagram.
 - 3) Inspect for proper anchorage and grounding. Verify engine cooling and fuel system integrity.
 - b. Electrical and Mechanical Tests:
 - 1) Perform a dielectric absorption test on generator winding with respect to ground. Determine polarization index.

- 2) Perform phase rotation test to determine compatibility with load requirements.
 - 3) Test protective relay devices in accordance with applicable sections of these specifications.
 - 4) Perform dc over potential test between winding and ground.
2. Automatic Transfer Switches:
- a. Visual and Mechanical Inspection:
 - 1) Inspect for physical damage.
 - 2) Verify that the short circuit withstand rating exceeds the available short circuit duty.
 - 3) Compare equipment nameplate information and connections with single line diagram and report any discrepancies.
 - 4) Check switch to ensure positive interlock between normal and alternate sources. (Mechanical and Electrical).
 - 5) Check tightness of all control and power connections.
 - 6) Perform manual transfer operation.
 - 7) Ensure manual transfer warnings are attached and visible to operator.
 - b. Electrical Tests:
 - 1) Perform insulation resistance tests phase-to-phase and phase-to-ground with switch in both source positions.
 - 2) Measure contact resistance in normal and alternate source position.
 - 3) Set and calibrate in accordance with the project electrical engineer's specifications.
 - a) Voltage and frequency sensing relays.
 - b) All time delay relays.
 - c) Engine start and shutdown relay.
 - 4) Perform automatic transfer by tests.
 - a) Simulating loss of normal power.
 - b) Return to normal power.
 - c) Simulating loss of emergency power on return to normal.
 - d) Simulate all forms of single phase conditions.
 - 5) Monitor and verify correct operation and timing.
 - a) Normal voltage sensing relays.
 - b) Engine start sequence.
 - c) Time delay upon transfer.
 - d) Alternate voltage sensing relays.
 - e) Automatic transfer operation.
 - f) Interlocks and limit switch function.
 - g) Timing delay and retransfer upon normal power restoration.
 - h) Engine cool down and shutdown feature.
- H. Grounding Grids or Electrodes: Measurement of resistance from ground grids or electrodes to earth to determine adequacy of grounding system in building and compliance with specifications and/or electrical code.

- I. Settings of Adjustable Devices: Using the result of the fault current and coordination study specified hereinafter, the Testing Contractor shall set all adjustable devices.
- J. In addition to the testing requirements of this Section refer to Section 01 81 00 –COMMISSIONING, for additional requirements.

3.16 FAULT CURRENT, ARC FLASH AND COORDINATION STUDY

- A. Trade Contract:
 - 1. Work of this Section is part of the Electrical trade contract. Refer to Section 26 00 00 for additional information about this work.
- B. Related Documents:
 - 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. Scope:
 - 1. The Electrical SubContractor shall furnish short-circuit and protective device coordination studies as prepared by the manufacturer of the switchgear provided for the project.
 - 2. The Electrical SubContractor shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in the current version of NFPA 70E -Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE Standard 1584 – 2002, the IEEE Guide for Performing Arc-Flash Calculations.
 - 3. The scope of the studies shall include new distribution equipment supplied by switchgear manufacturer furnishing the electrical distribution equipment for this project.
- D. References:
 - 1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
 - b. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
 - c. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
 - d. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
 - e. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
 - f. IEEE 1584 -Guide for Performing Arc-Flash Hazard Calculations
 - 2. American National Standards Institute (ANSI):
 - a. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
 - b. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures

- c. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - d. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single- Pole Air Switches, Fuse Disconnecting Switches and Accessories.
- 3. The National Fire Protection Association (NFPA)
 - a. NFPA 70 -National Electrical Code, latest edition
 - b. NFPA 70E – Standard for Electrical Safety in the Workplace
- E. Submittals For Review/Approval:
 - 1. The studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the study may cause delays in equipment shipments, approval from the Engineer may be obtained for a preliminary submittal of data to ensure that the selection of device ratings and characteristics will be satisfactory to properly select the distribution equipment. The formal study will be provided to verify preliminary findings.
- F. Submittals For Construction:
 - 1. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. A minimum of five (5) bound copies of the complete final report shall be submitted. For large system studies,
 - 2. Requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short- circuit input and output data. Electronic PDF copies of the report shall be provided upon request.
 - 3. The report shall include the following sections:
 - a. Executive Summary including Introduction, Scope of Work and Results/Recommendations.
 - b. Short-Circuit Methodology Analysis Results and Recommendations
 - c. Short-Circuit Device Evaluation Table
 - d. Protective Device Coordination Methodology Analysis Results and Recommendations
 - e. Protective Device Settings Table
 - f. Time-Current Coordination Graphs and Recommendations
 - g. Arc Flash Hazard Methodology Analysis Results and Recommendations including the details of the incident energy and flash protection boundary calculations, along with Arc Flash boundary distances, working distances, Incident Energy levels and Personal Protection Equipment levels.
 - h. Arc Flash Labeling section showing types of labels to be provided. Section will contain descriptive information as well as typical label images.
 - i. One-line system diagram that shall be computer generated and will clearly identify individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location, device numbers used in the time-current coordination analysis, and other information pertinent to the computer analysis.
- G. Qualifications:

1. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the responsible charge and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies.
 2. The Registered Professional Electrical Engineer shall be an employee of the equipment manufacturer.
- H. The approved engineering firm shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analyses it has performed in the past year.
- I. Computer Analysis Software:
1. The studies shall be performed using SKM Systems Analysis Power*Tools for Windows (PTW) software program.
- J. Studies:
1. The Electrical SubContractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E -Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D. This study shall also include short-circuit and protective device coordination studies.
- K. Data:
1. Electrical SubContractor shall furnish all data as required for the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Electrical SubContractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.
 2. Source combination may include present and future motors and generators.
 3. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner, or General Contractor.
 4. If applicable, include fault contribution of existing motors in the study. The Electrical SubContractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.
- L. Short-Circuit Analysis:
1. Transformer design impedances shall be used when test impedances are not available.
 2. Provide the following:
 - a. Calculation methods and assumptions
 - b. Selected base per unit quantities
 - c. One-line diagram of the system being evaluated that clearly identifies individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location and other information pertinent to the computer analysis
 - d. The study shall include input circuit data including electric utility system characteristics, source impedance data, conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short-circuit calculations.

- e. Tabulations of calculated quantities including short-circuit currents, X/R ratios, equipment short-circuit interrupting or withstand current ratings and notes regarding adequacy or inadequacy of the equipment rating.
 - f. Results, conclusions, and recommendations. A comprehensive discussion section evaluating the adequacy or inadequacy of the equipment must be provided and include recommendations as appropriate for improvements to the system.
- 3. For solidly-grounded systems, provide a bolted line-to-ground fault current study for applicable buses as determined by the engineer performing the study.
 - 4. Protective Device Evaluation:
 - a. Evaluate equipment and protective devices and compare to short circuit ratings
 - b. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short- circuit stresses
 - c. Switchgear Manufacturer shall notify Owner in writing, of any circuit protective devices improperly rated for the calculated available fault current.

M. Protective Device Time-Current Coordination Analysis:

- 1. Protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.
- 2. Include on each TCC graph, a complete title with descriptive device names.
- 3. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
- 4. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
- 5. Plot the following characteristics on the TCC graphs, where applicable:
 - a. Electric utility's overcurrent protective device
 - b. Medium voltage equipment overcurrent relays
 - c. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
 - d. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
 - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves
 - f. Medium voltage conductor damage curves
 - g. Ground fault protective devices, as applicable
 - h. Pertinent motor starting characteristics and motor damage points, where applicable
 - i. Pertinent generator short-circuit decrement curve and generator damage point
 - j. The largest feeder circuit breaker in each motor control center and applicable panelboard.
- 6. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.
 - a. Provide the following:
 - 1) A One-line diagram shall be provided which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known.
 - 2) A sufficient number of log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the time-current

- characteristics of series connected overcurrent devices and other pertinent system parameters.
- 3) Computer printouts shall accompany the log-log plots and will contain descriptions for each of the devices shown, settings of the adjustable devices, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.
- 4) The study shall include a separate, tabular printout containing the recommended settings of all
- 5) adjustable overcurrent protective devices, the equipment designation where the device is located, and the device number corresponding to the device on the system one-line diagram
- 6) A discussion section which evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations as required for addressing system protection or device coordination deficiencies.
- 7) Switchgear Manufacturer shall notify Owner in writing of any significant deficiencies in protection and/or coordination. Provide recommendations for improvements.

N. Arc Flash Hazard Analysis:

1. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2009, Annex D. The arc flash hazard analysis shall be performed in conjunction with the short-circuit analysis (Section 2.03) and the protective device time-current coordination analysis (Section 2.04).
 2. The flash protection boundary and the incident energy shall be calculated at significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.
 3. Circuits 240V or less fed by single transformer rated less than 125 kVA may be omitted from the computer model and will be assumed to have a hazard risk category 0 per NFPA 70E.
 4. Working distances shall be based on IEEE 1584. The calculated arc flash protection boundary shall be determined using those working distances.
 5. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations
 6. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location in a single table. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum. Conversely, the maximum calculation will assume a maximum contribution from the utility. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by generator applications.
- The Arc-Flash Hazard Analysis shall be performed utilizing mutually agreed upon facility operational conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.

7. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors should be decremented as follows:
 - a. Fault contribution from induction motors should not be considered beyond 5 cycles.
 - b. For each piece of ANSI rated equipment with an enclosed main device, two calculations shall be made. A calculation shall be made for the main cubicle, sides, or rear; and shall be based on a device located upstream of the equipment to clear the arcing fault. A second calculation shall be made for the front cubicles and shall be based on the equipment's main device to clear the arcing fault. For all other non-ANSI rated equipment, only one calculation shall be required and it shall be based on a device located upstream of the equipment to clear the arcing fault.
 8. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.
 9. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.
 10. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. A maximum clearing time of 2 seconds will be used based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.
 11. Provide the following:
 - a. Results of the Arc-Flash Hazard Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, working distances, personal-protective equipment classes and AFIE (Arc Flash Incident Energy) levels.
 - b. The Arc-Flash Hazard Analysis shall report incident energy values based on recommended device settings for equipment within the scope of the study.
 - c. The Arc-Flash Hazard Analysis may include recommendations to reduce AFIE levels and enhance worker safety.
- O. Field Adjustment:
1. Electrical SubContractor shall adjust relay and protective device settings according to the recommended settings table provided by the coordination study.
 2. Electrical SubContractor shall make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
 3. Switchgear manufacturer shall notify the design engineer in writing of any required major equipment modifications.
- P. Arc Flash Labels:
1. Electrical SubContractor shall provide a 4.0 in. x 4.0 in. Brady thermal transfer type label of high adhesion polyester for each work location analyzed.
 2. The labels shall be designed according to the following standards:
 - a. UL969 – Standard for Marking and Labeling Systems
 - b. ANSI Z535.4 – Product Safety Signs and Labels

- c. NFPA 70 (National Electric Code) – Article 110.16
- 3. The label shall include the following information:
 - a. System Voltage
 - b. Flash protection boundary
 - c. Personal Protective Equipment category
 - d. Arc Flash Incident energy value (cal/cm²)
 - e. Limited, restricted, and prohibited Approach Boundaries
 - f. Study report number and issue date
- 4. Labels shall be printed by a thermal transfer type printer, with no field markings.
- 5. Arc flash labels shall be provided for equipment as identified in the study and the respective equipment access areas per the following:
 - a. Floor Standing Equipment - Labels shall be provided on the front of each individual section. Equipment requiring rear and/or side access shall have labels provided on each individual section access area. Equipment line-ups containing sections with multiple incident energy and flash protection boundaries shall be labeled as identified in the Arc Flash Analysis table.
 - b. Wall Mounted Equipment – Labels shall be provided on the front cover or a nearby adjacent surface, depending upon equipment configuration.
 - c. General Use Safety labels shall be installed on equipment in coordination with the Arc Flash labels. The General Use Safety labels shall warn of general electrical hazards associated with shock, arc flash, and explosions, and instruct workers to turn off power prior to work.

3.17 STORAGE AND INSTALLATION OF EQUIPMENT

- A. The electrical subcontractor shall store and install electrical equipment and wiring listed for dry locations only after the building is watertight.

3.18 WASTE MANAGEMENT

- A. Separate and recycle materials and material packaging in accordance with Waste Management Plan and to the maximum extent economically feasible and place in designated areas for recycling.
- B. Set aside and protect materials suitable for reuse and/or remanufacturing.
- C. Separate and fold up metal banding; flatten and place along with other metal scrap for recycling in designated area.
- D. Coordinate with Section 013543 –ENVIRONMENTAL PROTECTION PROCEEDURES

3.19 TRAINING

- A. All training shall be scheduled with the user. Training shall be videotaped and a thumb drive delivered to the Owner. Refer to each specific system for amount of training required.

3.20 SPARE PARTS/ATTIC STOCK:

A. REQUIREMENTS:

1. Provide attic stock of the following quantities and parts for each piece of equipment as follows and in addition to spare/attic stock already included in previous specification sections:

Equipment/Unit	Parts Description	Quantity
Lighting Fixtures	LED Drivers	5% of each type not fewer than 2
	Single faced exit signs	10% of total signs not less than 10
	Double faced exit signs	10% of total signs not less than 10
	Louvers, Lenses, Baffles	1% of each type not fewer than 2
	MC Cable	100 feet for each exit sign owned in the extra material section.
Fire Alarm	Smoke detectors of each type (Duct, ceiling)	Provide 3 of each type for attic stock
	Heat Detector	Provide 3 for attic stock.
	Pull stations	Provide 3 for attic stock.
	Spare printer ribbon	Provide 2 for attic stock
	Extra set of keys and tools for access to locked and tamperproof components	Provide 3 for attic stock
Lighting Controls	Multi-tech Occupancy Sensors	Provide 10 for attic stock
	Photo-Sensors	Provide 10 for attic stock
	I/O modules	Provide 10 for attic stock
	Standard zone control switch	Provide 10 for attic stock.

3.21 TRAINING

- A. All training shall be scheduled with the user. Training shall be professionally videotaped and a thumb drive delivered to the Owner. Refer to each specific system for amount of training required.

END OF SECTION

SECTION 27 00 00
COMMUNICATIONS
(Filed Sub-Sub Bid Required)

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SECTION 27 00 00
COMMUNICATIONS
(Filed Sub-Sub Bid Required)

PART 1 - GENERAL

1.01 FILING OF FILED SUB-SUB BIDS

- A. Filed Sub-Sub-Bid Requiring a Paragraph "E" Listing on the FORM FOR SUB-BID required per M.G.L. Chapter 149 Section 44A to 44L, as amended to date. The Electrical Subcontractor will be responsible for all related building preparation and coordination, see specification for additional Paragraph "E" Listing requirements of the Listed Systems Contractor, and coordination of responsibilities.
- B. Section 27 00 00 TECHNOLOGY, shall be a Filed Sub-Sub Bid of Section 26 00 00 ELECTRICAL, requiring a Paragraph "E" Listing on the FORM FOR SUB-BID

1.02 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 GENERAL REQUIREMENTS

- A. The Conditions of the Contract and General Requirements of the Project Manual apply to this Subcontractor, material suppliers, and all other persons furnishing labor and materials under this Section. The General Conditions, and applicable parts of Division 01 are included as part of this Section.
- B. Examine all Project Specifications and Drawings for requirements which affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.
- D. The following definitions apply to the Drawings and Specifications:
 - 1. Furnish: The term "furnish" is used to mean "supply and deliver to the Project Site, ready for unloading, unpacking, assembly, installation, and similar operations".
 - 2. Install: The term "install" is used to describe operations at the Project Site including actual "unloading, unpacking, assembly, erection, piecing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations".
 - 3. Provide: The term "provide" is used to mean "furnish and install, complete and ready for the intended use".
 - 4. Installer: An "installer" is the Contractor or an entity engaged by the Contractor, either as an employee, Subcontractor, or Sub-Subcontractor for performance of a particular construction activity, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.

- E. When open-flame or spark producing tools such as blow torches, welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four (24) hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant non-working fire watch where work is being performed until it is completed.

1.04 QUALITY ASSURANCE

- A. Sustainable Goals: The Architect has designed the project to meet the Owner's sustainable goals. Products and systems have been specified which meet certain third-party evaluations or have particular VOC and source requirements. Evaluation of products proposed for substitution will be evaluated based on the Owner's sustainable goals and other criteria included in Division 01. The Contractor is encouraged to use sustainable construction practices, means and methods. Unless specifically stated in a specification section, no sustainable design documentation is required of the Contractor.

1.05 COOPERATION AND COORDINATION WITH OTHER TRADES

- A. The work shall be so performed that the progress of the entire building construction, including all other trades, shall not be delayed and not interfered with. Materials and apparatus shall be installed as fast as conditions of the building will permit and must be installed promptly when and as directed.
- B. This Section shall be furnish/installed as follows by a single firm/company that is a qualified systems contractor. The Electrical Subcontractor shall be responsible for properly preparing the project for installation by systems contractor, as specified.
 - 1. Electrical Subcontractor responsibilities shall include: The Electrical Subcontractor shall be responsible for furnishing and installing all related building preparation including, but not limited to: outlet boxes with plaster rings, floor boxes, poke through devices, pathways, power, cableways, cable tray, cable protection, wiremold, surface raceways, cable supports, J hooks, conduits with bushings, conduit stubs with bushings, sleeves with bushings (all conduits, stubs, sleeves, etc. shall be brought to an accessible ceiling or accessible area below floor), pull strings, bonding, grounding, core drilling, cutting, patching, environmental seals, seismic supports, supplementary steel and channels, etc., for a completely operational system, as specified. The Electrical Subcontractor shall also accept delivery and properly store & secure all equipment and materials required by the systems contractor. The Electrical Subcontractor shall install all specialized backboxes and any exterior antennas furnished by Systems Contractor.
 - a. The Electrical Subcontractor shall provide cable tray over each rack and cabinet as required to facilitate a neat and orderly installation of cables and to secure the top of the racks to the structure. Cables shall drop straight down to equipment racks. Cable trays shall be secured at both ends to the structure and connected together as required for a complete contiguous installation. Utilize proper supports to support the cable tray to the building structure as well as the equipment rack and cabinet. Submit mounting supports for approval before installation.

- b. This entire Section: The Electrical Subcontractor shall read this section in its entirety and shall provide all requirements of the Electrical Subcontractor as detailed in this Section.
- 2. Systems Contractor responsibilities for this section shall be: Systems contractor shall be responsible for providing, installing, programming, troubleshooting, training and warranty service of all cabling, terminal equipment, headend equipment specified in this section for a completely operational system.
 - a. Keep fully informed as to the shape, size and position of all openings required for all apparatus and give information in advance to build openings into the work. The electrical subcontractor shall furnish and set in place all sleeves, pockets, supports and incidentals.
 - b. All distribution systems which require pitch or slope such as plumbing drains, steam and condensate piping shall have the right of way over those which do not. Confer with other trades as to the location of pipes, ducts, lights and apparatus and install work to avoid interferences.
 - c. Coordinate exact locations and roughing in dimensions of all work before installation and make all final connections as required. Any changes required to avoid interferences or to provide adequate clearances for Code and maintenance requirements shall be made at no additional costs.
 - d. Structural elements of the project shall not be relocated, altered or changed to accommodate the work without written authorization from the Architect.
 - e. Work that is installed before coordination with other trades or that causes interference with the work of other trades shall be changed to correct condition.
 - f. Obtain a complete set of Project Drawings and Specifications for coordination and to determine the full scope of work.
 - g. Attend project coordination meetings to coordinate work of this Section, work of other trades and project and phasing requirements.

1.06 SUBMITTALS

- A. Product Data for all materials specified and shown on drawings to be installed.
- B. Equipment List: Provide a detailed Equipment List showing quantities by manufacturer and model number of all major items of equipment and installation material to be used in the system as specified herein.
- C. Submit supporting hardware for this system as part of the work for approval prior to installation.
- D. Product Data: Include complete sets of indexed cut sheets, in quantity as dictated by the project, of all major pieces of equipment and materials being supplied. Arrange these sheets in the order the equipment appears in the Specification. Clearly highlight information showing compliance with this and/or all applicable Specifications. In the event that the manufacturer or representatives' cut sheet contains more than one item, clearly indicate which items of the cut sheet are intended for installation.
- E. Shop Drawings: Submit a set of complete Shop Drawings, by system, showing equipment to be installed. Include system configuration block diagrams of all equipment, indicating equipment type and model numbers. Show each and every component, system and subsystem, as well as all

proposed connections between system components, and proposed layouts of equipment racks for the entire system.

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. Cabling administration drawings and printouts.
3. Wiring diagrams to show typical wiring schematics including the cross-connects.
4. Cross-connects. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
5. Cross-connects and patch panels. Detail mounting assemblies and show elevations and physical relationship between the installed components.
6. Cable tray layout showing cable tray route to scale with relationship between the tray and adjacent structural, electrical and mechanical elements.

F. Quality Assurance Submittals:

1. Provide manufacturer's certification that Installer is qualified to install systems specified. Include a written statement signed by the Installer attesting that they have been in business for at least five years in the installation and servicing of systems specified. Include the names of at least five clients for whom similar Work as specified has been performed in the past three years; list the individual responsible for the day-to-day operation of the system along with their current telephone number and address.
2. Provide names, qualifications, and certifications of installation personnel including Communication Systems Installer's site Supervisor/Foreman who shall be in charge of, and responsible for, all activities at the job site for the duration of the Project. The job Supervisor/Foreman shall not be changed during the project without notification and approval from the Owner.
3. Complete warranty information including sample Registration Certificate.
4. Technical Diagrams and Drawings:
 - a. Simplified single line block diagrams showing the interconnection of all equipment and functional relationships. Show all equipment, patch panels, cables and jacks, whether connected or not. The intent of these diagrams is to provide sufficient clear and complete information that a technician of average skill may efficiently troubleshoot and service the system, even if unfamiliar with the installation.
 - b. Provide "As Built" architectural quality plan Drawings at 1/8 in. = 1 ft.-0 in. scale. Provide an electronic copy of the "As Built" drawings on CD(s).
 - c. All technical diagrams and drawings shall be mounted on the wall behind a clear plastic cover for protection. There shall be one set of the above drawings and diagrams provided for the MDF Room.

1.07 TELEPHONE/DATA SYSTEM

A. General:

1. All telecommunication and data system interconnecting wiring, terminal blocks, connections, terminations, shall be furnished and installed by a licensed and certified installer.
2. The Electrical Subcontractor (E.C.) shall furnish and install all raceways, and outlet boxes as indicated on the drawings, including pull wires for all empty raceways and all access

panels. General contractor will furnish and install all backboards (3/4 in. thick by 78 in. high) which shall be mounted at the MDF room.

3. General Requirements:

a. Applicable Standards:

1) Materials and equipment shall be installed in accordance with the most current versions of the National Electrical Code, local codes, safety codes, ANSI, ASTM, EIA, TIA, BISCI, IEEE, UL, NFPA.

a) The following industry standards are the basis for the structured cabling system described in this document.

ANSI/TIA/EIA

TIA/EIA-568-B	Commercial Building Telecommunications Cabling Standard

TIA/EIA-568-B.1	General Requirements

TIA/EIA-568-B.2	Balanced Twisted Pair Cabling Components Standard

TIA/EIA-568-B.3	Optical Fiber Cabling Components Standard

TIA/EIA - 942	Telecommunications Infrastructure for Data Centers

TIA/EIA-569-A	Commercial Building Standard for Telecommunications Pathway and Spaces

TIA/EIA-606-A	Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

J-STD-607-A	Commercial Building Grounding/Bonding Requirements NFPA

NFPA 70	National Electric Code (NEC) ISO/IEC

ISO 11801	Generic Cabling for Customer Premises

EIA/TIA-TSB 67.	Telecommunications Systems Bulletin, Additional Transmission Specifications for Unshielded Twisted-Pair Cabling Systems"

EIA/TIA-455-61.	"FOTP-61, Measurement of Fiber or Cable Attenuation Using An OTDR".

IEEE 802.3	"Carrier Sense Multiple Access With Collision Detection".

ATM	Forum Standard for 155 Mb/s ATM over Category 6 (AF-PHY-0015.000, 9/94)

BISCI:	Telecommunications Distribution Methods and LAN Design Manual

IEEE-802:	Standards for Local Area Networking

UL	Performance Levels Certification Program

ANSI-IEEE-C2:	National Electrical Safety Code (NESC)

ANSI/NFPA-101: Life Safety Code

Massachusetts Electric Code CMR527

- b. Exposed wiring is not acceptable in any occupied space.
- c. Contractor is responsible for strict adherence to Massachusetts electrical codes, and all other applicable codes.
- d. The contractor is responsible for obtaining municipal permits and inspections as mandated by law.
- e. All exposed cabling shall be run in raceway or conduit.
- f. All penetrations in station raceway shall have rubber or equivalent grommets to prevent cable cuts on rough edges.
- g. Raceway shall be of sufficient size to accommodate all wiring. Fill density not to exceed 40 percent, unless otherwise noted. It is the responsibility of the bidder to determine the size needed based upon the floor plans provided. A minimum size of 1 in. conduit shall be adhered to, U.N.O or approval by the engineer.
- h. All raceways shall be attached to the building structure using screws and anchors.
- i. The I.T. subcontractor is responsible for all aspects of MDF construction. Refer to drawings for configuration of each MDF.
- j. All cabling at the MDF shall be neatly bundled and dressed to the termination blocks. All appropriate cable management materials (slotted duct, D rings, etc.) should be utilized for this purpose.
- k. All labeling of cables shall be 6 in. back from the termination with machine generated labels, hand written labels are not permitted.
- l. All cable pulls in conduit, raceway, innerduct, etc. shall have pull string left in place for future use.
- m. Color code identification of cables must be maintained throughout all splices.
- n. All station cabling shall be clearly and legibly labeled at both the faceplate end and the MDF termination blocks. In addition to labeling both the inside of the faceplates and MDF termination blocks, the cable jacket shall be labeled six inches back from the terminations on both ends. Labeling shall be machine generated.
- o. Labeling of the outside of the jack with identification numbers shall be made using a Panduit LS8 handheld label machine or equal. Samples shall be provided to Engineer for approval prior to installation; the labeling scheme shall be submitted for review and approval, coordinate with the IT Department prior to submitting.
- p. In order to qualify for installation of the data communications system, Contractor must possess the required license classification, a performance history, experience in the installation and termination of optical fiber cable systems, and proof of time in business. Contractor must be trained and certified for the communications cable and hardware which it installs, and must furnish proof of certification.
- q. License Classification: Contractor must possess a valid state Contractor's License.

- B. Unless otherwise indicated, the following work is not included as part of the systems integrator's responsibilities in this SECTION, except for coordination, and is to be performed by others as indicated:

- 1. Raceway shall be provided by the electrical contractor.
- 2. Empty conduits to accessible point above ceiling or below floor shall be provided by the electrical contractor.
- 3. Floor boxes and poke through devices shall be provided by the electrical contractor.
- 4. Standard device boxes with plaster rings for data and Integrated Instructional Technology Network System shall be provided by the electrical contractor.

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5. Speaker/paging system backboxes shall be installed by the electrical contractor and provided by this systems integrator.
6. Structural blocking to support wall and ceiling mounted televisions/monitors shall be provided by the General Contractor.
7. Interface with public utilities telephone service shall be arranged by the owner, and coordinated with this systems integrator.
8. Telephone equipment and handsets will be provided under a separate contract.

1.08 DEFINITIONS

- A. Main Cross Connect (MC): The MC is the location, within a building or complex of buildings, where the entire telecommunications system originates. It may include: the physical location, enclosure, wire and cable management hardware, termination hardware, distribution hardware, and patching and equipment racks.
- B. Horizontal Cross Connect (HC): The HC is the location in a building where a transition between the backbone or vertical riser system and the horizontal distribution system occurs.
- C. Designated Critical Operations Areas (DCOA) areas within a facility or site designated as requiring critical operations power.
- D. Telecommunications main ground bar (TMGB)

1.09 SYSTEM DESCRIPTION

- A. The data communications system shall consist of four components, active switch equipment, an optical fiber backbone, a copper twisted-pair backbone, and twisted pair copper work station cabling.
- B. The audio-visual systems shall consist of wiring, jacks, amplification equipment, control equipment and interface with owners VOIP phone system and Station alerting system.
- C. The work under this Section includes providing of all material, labor, equipment and supplies and the performance of all operations to provide a complete working Integrated Instructional Technology Network System as required by the Drawings and details and as specified herein. Where the Drawings, Specifications, Codes, Regulations, Laws, or the requirements of the local Authority conflict, provide the higher quality and higher quantity indicated or required and follow the strictest requirement. In general, the work includes, but is not limited to, the following:
 1. Cabling for Sound per manufacturers requirements.
 2. Equipment Racks and Cabinets.
 3. Relay Brackets.
 4. Terminations.
 5. Protection of all work.
 6. Record Drawings and Documentation.
 7. Staging.
 8. Telephone and data cabling.
 9. Data network racks and patch panels
 10. Operation and Maintenance Instructions and Manuals for the Section's work.
 11. Nameplates, Labels and Tags.

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12. Testing and certification.
13. Coordination with manufacturers, other trades and Owner.
14. CATV wiring, amps and splitters.
15. Paging system including amps, mixer, telephone interface and speakers.
 - a. Interface with owners telephone system and Station alerting system
16. Provide and maintain in safe adequate condition all staging and scaffolding required for the proper execution of the work of this Section.
17. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

D. Provide and maintain in safe adequate condition all staging and scaffolding required for the proper execution of the work of this Section.

E. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.10 PROTECTION OF WORK AND PROPERTY

- A. Be responsible for the care and protection of all work included under this Section until it has been tested and accepted.
- B. Protect all equipment and materials from damage from all causes including theft. All materials and equipment damaged or stolen shall be replaced with equal material or equipment at the option of the Architect and Owner.
- C. Materials and equipment stored for this project shall be protected and maintained according to the manufacturer's recommendations and requirements and according to the applicable requirements of NFPA 70B.
- D. Protect all equipment, outlets and openings with temporary plugs, caps and covers. Protect work and materials of other trades from damage that might be caused by work or workmen and make good any damage caused.
- E. Use caution to avoid damage to existing work, and to prevent harm to personnel working in all areas.
- F. Observe all safety precautions and requirements for the construction.
- G. When open-flame or spark producing tools such as blower torches, welding equipment, etc., are required in the process of executing the work, the General Contractor shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where the work is to be performed. Provide, where necessary, fire protective covering and maintain a constant non-working fire watch where work is being performed and until it is completed.
- H. The General Contractor and the Installer are responsible for initiating, maintaining, and supervising all safety precautions and requirements during construction.

1.11 SEQUENCING AND SCHEDULING

- A. Coordinate the work of this Section with the respective trades responsible for installing interface work, and ensure that the work performed hereunder is acceptable to such trades for the installation of their work.
- B. Continuity of all services shall be maintained in all areas which will be occupied or temporarily relocated during the construction period. If an interruption of service becomes necessary, such shall be scheduled in advance, made only upon consent of the Owner and at a time outside normal working hours as the Owner shall designate.
- C. Refer to the overall scheduling of the work of the project. Schedule work, process Submittal and order materials and equipment to conform to this schedule and install work to not delay nor interfere with the progress of the project.
- D. Inform Architect immediately of any delays or potential delays. Furnish manufacturer's letter to verify order date, equipment delays, expected shipment date, order number, and potential remedies to speed up delivery. Any costs to speed up delivery shall be implemented at no cost to the project if the equipment or material was not ordered as soon as possible after Contract award or within the time frames indicated with the Submittal.
- E. Include premium time required to comply with the project scheduling and phasing.
- F. Be aware of, and plan for, project scheduling and phasing. Provide for complete continuous operation of all systems. Coordinate scheduling and phasing with the Architect, Owner, other Trades, and the General Contractor.

1.12 WARRANTY

- A. Voice and Data Cabling Warranty: The products that shall best support the needs of the project, and provide the highest level of system performance over the life of the facility, shall be a voice and data cabling system that is made up of system components designed, manufactured and installed as a total system solution. This requirement also applies to data patch cords specified in this Section; e.g. Ortronics patch cords shall be used with Ortronics jacks and patch panels.
- B. Provide a Manufacturer's Extended Product Warranty that covers product defects for all passive components of the Voice and Data Cabling System. Passive components are defined as those exhibiting no gain or contributing no energy to the Data Cabling System and include but are not limited to cabling, connectors, outlets, patch panels, patch cords, racks as outlined in PART 2 of this Specification.
 - 1. The following shall be covered by the Manufacturer's Extended Product Warranty:
 - a. All passive components that comprise the Voice and Data Cabling System will be free from manufacturing defects in material of workmanship under normal and proper use.
 - b. All passive components that comprise the Voice and Data Cabling System shall exceed the specifications of ANSI/TIA/EIA 568B series, and exceed ISO/IEC 11801 standards, including all subsequent changes to these standards that are in effect at the time of bidding, and shall meet or exceed the performance specifications as outlined in PART 2 of this Specification.
 - c. The installation shall exceed the insertion and return loss, attenuation and near end

crosstalk (NEXT) requirements of ANSI/TIA/EIA 568B series and the ISO/IEC 11801 standards for cabling links/channel configurations specified in these standards including all subsequent changes to these standards that are in effect at the time of bidding.

- d. Each Voice and Data Channel shall be capable of delivering data at 1.2 Gbps between active network electronics. A Data Channel is comprised of all passive components including cabling, connectors, patch panel port, and patch cords, with up to a total of 4 connections between Owner's network electronics (not in the contract).
- e. Upon successful completion of the Voice and Data Cabling System installation by the Communication Systems Installer, and subsequent inspection by an authorized representative of the Manufacturer of the passive components, the Owner shall be provided with Registration Certificate, from the Manufacturer, registering the Installation.
- f. Duration of Warranty: The warranty shall run for 20 years from the Date of Substantial Completion of the Project, unless the Registration Certificate is issued by the Manufacturer at a later date, in which case the warranty shall run for 20 years from the date that the Registration Certificate is issued.
- g. The Extended Product Warranty is applicable to the Voice and Data Cabling System passive components at the original site of installation. Under the Extended Product Warranty, the Manufacturer of the passive components shall either repair or replace the defective product(s) at the Manufacturers cost. This includes the replacement or repair cost of defective materials and the cost of labor to repair or replace any and all defective products.
- h. The Communication Systems Installer shall provide a Manufacturer's warranty that the Voice and Data Cabling System shall be free from defects which prevent operation of the specific applications for which the original Voice and Data Cabling System was designed to support, including but not limited to: 10Base-T; 100Base-T; 52/155 Mbps ATM; 622Mbps 64-CAP ATM; 1000Base-T Gigabit Ethernet.

1.13 MAINTENANCE

- A. Provide installers maintenance contract quote, upon request, for a period equal to warranty.
- B. Upon receipt of notice from the Owner of failure of any part of the systems during the warranty period, the affected parts shall be replaced. Any equipment requiring excessive service consisting of more than two unscheduled service calls, shall be considered defective and shall be replaced.
- C. Response times to warranty issues shall differ according to the level of the problem.
 - 1. A problem is considered to be corrected when the system and its components operate according to specified requirements.
 - 2. Warranty work shall be performed according to the procedures of the Owner, its staff and tenants and their normal operations.

1.14 SEISMIC REQUIREMENTS

- A. Equipment and work shall meet the restraint requirements per Massachusetts Building Code.

1.15 FUNCTION AND OPERATION

- A. The intended function of the data communications cable system is to transmit data signals from a central location to several individual data outlet locations. Upon completion of the work outlined in this specification, the system shall be capable of transmitting data signals at a rate of 1000 Mbps.
- B. The multimode optical fiber cable system shall be capable of transmitting signals with a minimum bandwidth of 500 MHz at both 850 or 1300 nm. The cumulative signal loss, through connectors, jumpers, couplers, and fiber cable, shall be less than 10 dB. The singlemode optical fiber cable system shall be capable of transmitting signals with a bandwidth of up to 500 MHz at both 1300 and 1550 nm. The cumulative signal loss, through connectors, jumpers, couplers, and fiber cable, shall be less than 10 dB.
- C. Work station cable, from the HC to the work area, shall be installed in accordance with EIA/TIA-568-A specified installation practices, EIA/TIA TSB 67 recommended installation practices, manufacturer specified installation practices, and shall be capable of transmitting a signal at 1000 Mbps with acceptable attenuation and cross-talk measurements. The entire work station cable system, including wiring blocks, cable, and telecommunications outlets shall be tested for Category 6A compliance.

1.16 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Connecting Blocks: One of each type.
 - 2. UTP 4-pair Station Cable: 1,000 feet.
 - 3. UTP Backbone Cable: 300 feet.
 - 4. Patch-Panel Units: One of each type.
 - 5. Device Plate: 10 of each type.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Throughout Part 2, material quantities are given. These quantities are given for reference purposes only. It is the responsibility of the Contractor to provide appropriate quantities of materials to provide a complete, functional system.
- B. Equipment shall be installed in accordance with Technology drawings. General installation provisions are as follows:
 - 1. Equipment Racks: Equipment racks shall be assembled and mounted in locations shown in the Drawings and as described herein. Each rack shall be assembled in accordance with the manufacturer's instructions and recommendations. Each rack shall be mounted such that the side rails are plumb. Each rack shall be affixed to the building structure at each of the mounting holes provided. Attachment shall be by 1/2 in X 1-1/4 in. lag bolts. A 3/8" pilot hole shall be drilled for each lag bolt. Each bolt shall be tightened to the extent that it holds the mounting hardware firmly, but not so tight as to distort the hardware or strip the threads.

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Equipment racks are to be co-located with the quadplex power outlets to allow for easy connection of racked equipment to the power system.

2. Wiring Blocks and Wire Management Components: Where required, wiring blocks and wire management components shall be mounted to the plywood backboard. Wiring blocks and wire management shall be mounted in accordance with the attached drawings. Each device shall be mounted such that its horizontal dimension is level. In cases where more than one device is mounted, they shall be aligned vertically. Each device shall be affixed to the plywood backboard by means of screws suitable for fastening to plywood. A minimum of four of the mounting holes provided shall be utilized for fastening. Screws shall be tightened to the extent that they hold the device snug to the backboard, but not so tight as to distort or damage the device. Wiring blocks shall be terminated in accordance with the manufacturer's instructions and recommendations. Installation of accessories shall also be conducted in accordance with the manufacturer's instructions and recommendations.

2.02 COMMUNICATION EQUIPMENT ROOM FITTINGS

A. SUMMARY

Section Includes:

1. Telecommunications mounting elements.
2. Pathways
3. Telecommunications equipment racks and cabinets
4. Grounding.

- B. COORDINATION: Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
5. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

C. PATHWAYS

1. General Requirements: Comply with TIA/EIA-569-A.
2. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.

- a. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
- b. Support brackets with cable tie slots for fastening cable ties to brackets.
- c. Lacing bars, spools, J-hooks, and D-rings.
- d. Straps and other devices.

D. EQUIPMENT FRAMES (RACKS)

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. APC
 - b. Cooper B-Line, Inc.
 - c. Hubbell Premise Wiring.
 - d. Panduit
 - e. Or equal
2. Floor-Mounted Racks: Modular-type, four-post quick rail, aluminum construction.
 - a. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
 - b. Baked-polyester powder coat finish.
 - c. Refer to drawings for rack configurations.
3. Cable Management for Equipment Frames:
 - a. Metal, with integral wire retaining fingers.
 - b. Baked-polyester powder coat finish.
 - c. Vertical cable management panels shall have front and rear channels, with covers.
 - d. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.
4. Power Strips: Comply with UL 1363.
 - a. Rack mounting.
 - b. Receptacles: Six 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles for each power strip. Provide two in each rack. Power strip shall connect with a twist lock to match receptacle on cable tray.
 - c. LED indicator lights for power and protection status.
 - d. LED indicator lights for reverse polarity and open outlet ground.
 - e. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
 - f. Cord connected with 15-foot line cord.
 - g. Rocker-type on-off switch, illuminated when in on position.
 - h. Peak Single-Impulse Surge Current Rating: 33 kA per phase.
 - i. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all 3 modes shall be not more than 330 V.

E. GROUNDING

1. Comply with requirements in 26 00 00 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.
2. Telecommunications Main Bus Bar:

- a. Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
 - b. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide with 9/32-inch holes spaced 1-1/8 inches apart.
 - c. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
 - d. Comply with ANSI-J-STD-607-A.
3. Bond all racks and cable tray to TMGB.

F. LABELING

1. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.03 UTP CABLE (BACKBONE)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. General Cable
 2. CommScope
 3. Mohawk; a division of Belden CDT.
 4. Or equal
- B. Description: Multi-pair Backbone Cable: Category 5e, 100-ohm, 25-pair UTP binder groups covered with a gray thermoplastic jacket.
1. Comply with ICEA S-90-661 for mechanical properties.
 2. Comply with TIA/EIA-568-B.1 for performance specifications.
 3. Comply with TIA/EIA-568-B.2, Category 5e.
 4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - a. Communications: Type CMP, complying with NFPA 262.
- C. Multi-pair backbone cables: Provide copper backbone cable that meets or exceeds the following specifications:
1. Electrical Specifications:

Maximum DC Resistance	28.6 Ω /1,000 ft (9.4 Ω /100m)
Maximum DC Resistance Unbalanced	5 percent
Maximum Capacitance Unbalanced (pair to ground)	1,000 pF/1000 ft. (328 pF/m)
Mutual Capacitance @ 1kHz	18 nF/1000 ft (5.9 nF/100 m), max.
 2. Attenuation (dB/100 m [328 ft.]):

Frequency	Attenuation (Max.)

1.00 MHz	2.3 dB
4.00 MHz	4.9 dB
10.00 MHz	8.5 dB
16.00 MHz	12 dB

3. Worst Pair Near-End Crosstalk (NEXT) dB/100 m [328 ft]:

Frequency	Pair-To-Pair NEXT (Max.)
1.0 MHz	13.8 dB
4.0 MHz	11.2 dB
10.0 MHz	10.2 dB
16.0 MHz	9.2 dB

2.04 WORK STATION CABLE

A. DESCRIPTION: From each MDF, 4-pair enhanced Category 6A cables shall be routed to each work station (data outlets).

1. Product:

a. Copper 4-pair UTP:

1) UTP cables shall:

a) Be manufactured by one of the following:

- Hitachi Cable Manchester
- Berk-Tek
- Commscope
- General Cable
- Mohawk
- Or equal
- Be 100 Ω 4-pair, category 6A cable.

b. Shall be rated for the environment in which it is installed.

2. Required Accessories and Quantities (Hard Wall Locations):

- a. Work Station: Panduit CFPLS** stainless steel Single Gang, Single Port Face plate. Using Panduit CMB**-X blank modules to fill unused ports. Refer to drawings for two, three, and four gang configurations. Modules shall be CJ688TP** – color to be selected by engineer.

3. Work Area Equipment Cords: The Work Area Equipment Cords shall meet or exceed the following criteria:

- a. Modular Equipment Cords: Category 6A

4. Category 6A, modular equipment cords shall:

- a. Be round, and consist of eight insulated 24 AWG, stranded copper conductors, arranged in four color-coded twisted-pairs within a flame-retardant jacket.
 - b. Be equipped with modular 8-position (RJ45 style) plugs on both ends, wired straight-through with standards compliant wiring.
5. Use modular plugs which exceed FCC CFR 47 part 68 subpart F and IEC 60603-7 specifications, and have 50 microinches minimum of gold plating over nickel contacts.
6. Be resistant to corrosion from humidity, extreme temperatures, and airborne contaminants.
7. Utilize cable that exhibit power sum NEXT performance.
 - a. Be available in several colors with color strain relief boots featuring a snagless design.
 - b. Provide (2) foot patch cord per data jack shown on drawings. Coordinate with owner exact sizes required in the closet side.
 - c. Be made by an ISO 9001 and 14001 Certified Manufacturer.
 - d. Electrical Specifications:
 - e. DC resistance per lead: $9.38 \Omega / 100 \text{ m}$ maximum.
 - f. Input impedance without averaging: $100 \Omega + 15 \text{ percent}$ from 1 to 100 MHz.
 - g. 100% transmission tested with laboratory grade network analyzers for proper performance up to 1000 MHz. Vendor shall guarantee cords are compatible with category 6A links.
8. UL VERIFIED (or equivalent) for TIA/EIA proposed category 6A electrical performance.
9. UL LISTED 1863.
10. All information outlets for 100Ω 22-26 AWG copper cable shall:
 - a. Be available in blue, black, green, yellow, white, gray, ivory and light ivory.
 - b. Accommodate a minimum of two 8-position / 8-conductor modular jacks.
 - c. Utilize compliant pin technology 110 style insulation displacement connectors which allows the use of a 4-pair impact tool.
 - d. Allow for a minimum of 200 re-terminations without signal degradation below standards compliance limit.
 - e. Be constructed of high impact, flame-retardant thermoplastic.
 - f. Be available in a screened version for 100Ω ScTP cable.
 - g. Be made by an ISO 9001 and 14001 Certified Manufacturer.
 - h. Electrical Specifications:
 - i. ANSI/TIA/EIA-568-B1, B2, B3 and ISO/IEC 11801 proposed category 6 compliant.

- j. The following requirements shall also be met (NEXT Loss and FEXT tested in both Differential and Common Mode):

Parameters	Performance	Performance @ 100 MHz *
NEXT Loss	+ 3.0 dB	43.0 dB
FEXT	+ 3.0 dB	43.0 dB **
Insertion Loss (Attenuation)	+ 40 percent	.24 dB
Return Loss	+ 6 dB	20 dB
LCL	40 dB (1-100 MHz)	**

- B. INSTALLATION: Installation shall be conducted in accordance with guidelines established the manufacturer and industry standards. Wall Plates shall be mounted such that their vertical dimension is plumb. Each wall plate shall be labeled with its respective work station number. Each modular mounting frame shall be labeled with its respective work station number.
- C. Technical Requirements: Horizontal cabling: the horizontal subsystem is the portion of the telecommunications cabling system that extends from the work area telecommunications outlet/connector to the horizontal cross-connect in the Telecommunications room/closet. It consists of the telecommunications outlet/connector, the horizontal cables, optional consolidation point, and that portion of the cross-connect in the telecommunications room/closet serving the horizontal cable.

1. Cable Types: All UTP and fiber optic cables shall conform to the following standards:

- a. ANSI/TIA-568C.0 Generic Telecommunications Cabling for Customer Premises
- b. ANSI/TIA-568C.1 Commercial Building Telecommunications Cabling
- c. ANSI/TIA-568C.2 Balance Twisted Pair Telecommunications Cabling
- d. ANSI/TIA-568C.3 Optical Fiber Cabling and Components Standard
- e. Including all applicable addenda) and ISO/IEC 11801 (International) Generic Cabling for Customer Premises standard (latest amendment and including all applicable addenda).
- f.

Input	Bonded-Pair	Non-bonded Pair
Impedance		
100 +	12 1-20 MHz	-----
100 +	15 20-250 MHz	1-100 MHz
100 +	20 250-350 MHz	-----
100 +	22 350-625 MHz	100-200 MHz
100 +	32 -----	200-625 MHz

- g. Copper: The following cable specifications shall also be met by the cable manufacturer for 4-pair UTP, premium category 6A cables:

- 1) Attenuation: Qualified Cables shall exhibit worst case attenuation less than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable attenuation performance for selected frequency points of interest is also provided.

Attenuation Limits Table			
		System 6ASM	
Frequency Range		1-350 MHz	
Worst Case		$\leq 1.82\sqrt{f} + .017 \cdot f + \frac{0.20}{\sqrt{f}}$	
Frequency Points of Interest	MHz		
	100	19.8 dB	
	200	29 dB	
	300	35.3 dB	

- h. Near End Crosstalk (NEXT) Loss:

- 1) Qualified Cables shall exhibit worst case NEXT Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable NEXT Loss performance for selected frequency points of interest is also provided.

NEXT Loss Limits Table				
		System 6SM		
Frequency Range		1-350 MHz		
Worst Case Cable NEXT Loss		$\geq 76 - 15\log\left(\frac{f}{0.772}\right)$		
Frequency Points of Interest	MHz			
	100	44.3 dB		
	200	39.8 dB		
	300	37.1 dB		

i. Power Sum Near-End Crosstalk (PSNEXT) Loss:

- 1) Qualified Cables shall exhibit worst case PSNEXT Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable PSNEXT Loss performance for selected frequency points of interest is also provided.

PSNEXT Loss Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case PSNEXT Loss		$\geq 74 - 15\log\left(\frac{f}{0.772}\right)$	
Frequency Points of Interest	MHz		
	100	42.3 dB	
	200	37.8 dB	
	300	35.1 dB	

j. Equal Level Far-End Crosstalk (ELFEXT):

- 1) Qualified Cables shall exhibit worst case ELFEXT greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable ELFEXT performance for selected frequency points of interest is also provided.

ELFEXT Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case ELFEXT		$\geq 70 - 20\log\left(\frac{f}{0.772}\right)$	
Frequency Points of Interest	MHz		
	100	27.8 dB	
	200	22.7 dB	
	300	18.2 dB	

k. Power Sum Equal Level Far-End Crosstalk (PSELFEXT):

- 1) Qualified Cables shall exhibit worst case PSELFEXT Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable PSELFEXT performance for selected frequency points of interest is also provided.

PSELFEXT Loss Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case PSELFEXT		$\geq 67 - 20\log\left(\frac{f}{0.772}\right)$	
Frequency Points of Interest	MHz		
	100	24.8 dB	
	200	18.7 dB	
	300	15.2 dB	

l. Return Loss:

- 1) Qualified Cables shall exhibit worst case Return Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable Return Loss performance for selected frequency points of interest is also provided.

Return Loss Limits Table					
				System 6SM	
Frequency Range				1-350 MHz	
Worst Case Return Loss				Frequency (MHz)	Return Loss (dB)
				$\leq f < 10$ $10 \leq f < 20$ $20 \leq f \leq 300$	$21 + 4 \cdot \log(f) \text{ dB}$ 25 dB $25 - 7 \cdot \log(f/20)$
Frequency Points of Interest	MHz	-		20.1 dB 18 dB 16.8 dB	
	100				
	200				
	300				

- m. Propagation Delay (ANSI/TIA/EIA-568-A-1):

- 1) Qualified Cables shall exhibit worst case Propagation Delay less than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable Propagation Delay performance for selected frequency points of interest is also provided.

Propagation Delay Limits Table				
				System 6SM
Frequency Range				1-350 MHz
Worst Case Propagation Delay				$< 476 + \frac{36}{\sqrt{f_{\text{MHz}}}}$
Frequency Points of Interest	MHz			480 ns 479 ns 478 ns
	100			
	200			
	300			

n. Delay Skew (ANSI/TIA/EIA-568-A-1):

- 1) Qualified Cables shall exhibit worst case Delay Skew less than the values specified in the chart below per 100 m from 1 MHz to the highest referenced frequency value.

Delay Skew Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case Delay Skew	MHz			
	100			
	200			
	300			

o. Longitudinal Conversion Loss (LCL):

- 1) For all categories of 100 Ω unshielded and screened cables, the worst case calculated LCL for any pair in a 100 m cable shall not be less than 35 dB, from 1 MHz to the highest referenced frequency for each performance category. LCL measurements shall be performed in accordance with ITU-T Recommendation O.9 (November, 1988) or equivalent. Calculated LCL performance shall be determined by subtracting the test balun loss correction factor (as specified by the balun manufacturer) from the measured value at all frequencies.

LCL Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case Delay Skew	MHz			
	100			
	200			
	300			

p. Longitudinal Transfer Conversion Loss (LCTL):

- 1) For all categories of 100 Ω unshielded and screened cables, the worst case calculated LCTL for any pair in a 100 m cable shall not be less than 35 dB, from 1 MHz to the highest referenced frequency for each performance category. LCTL measurements shall be performed in accordance with ITU-T Recommendation O.9 (November, 1988) or equivalent. Calculated LCL performance shall be determined by subtracting the test balun loss correction factor (as specified by the balun manufacturer) from the measured value at all frequencies.

LCTL Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case Delay Skew	MHz			
	100		35 dB	
	200		35 dB*	
	300		35 dB*	

q. Attenuation to Crosstalk Ratio (ACR):

- 1) Using “pair-to-pair NEXT Loss”, all Qualified Cables shall exhibit worst case ACR performance for the specified frequency range shown in the following table.

ACR Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case ACR	MHz			
	1-80		24.1 dB	
	80-100		24.1 dB	
	1-100		24.1 dB	
	100-300		.5 dB	
PSACR Limits Table				
			System 6SM	
Frequency Range			1-350 MHz	
Worst Case PSACR	MHz			
	1-80		22.1 dB	
	80-100		22.1 dB	
	1-100		22.1 dB	
	100-300		-1.5 dB	

r. Transfer Impedance:

- 1) Surface+ Transfer Impedance is specified for ScTP cables and is determined by the formula below in $m\Omega/m$ where f = frequency. All qualified ScTP cables shall have a margin greater than or equal to the values specified in the following table.

$$T_{cable} = 37 + 4f + 4\sqrt{f} + 5\sqrt[3]{f}$$

Transfer Impedance Limits Table			
Margin 1-100 MHz		System 6SM	
Transfer Impedance		10 %	

2.05 MAIN DISTRIBUTION FACILITY (MDF)

A. DESCRIPTION: The equipment shall be installed in accordance with Drawings.

1. Products and Quantities:

- a. Equipment Rack: - As specified.
- b. Fiber Interconnect: Panduit FRME24 rack mount fiber optic enclosure or equal. Supply and install as many as necessary to service all fiber strands entering the MDF.
- c. Modular Patch Panels: Panduit angled patch panel or equal: 48-port patch panel wired Category 6A Patch Panel. One port for each workstation served from the MDF with a minimum of 12 spare ports are required. Provide CAT6A angled patch panel for wireless CAT6A ports. If the number of workstation cables, plus required spare count 12 is greater than 48, then a second 48-port patch panel is required. Supply and install as many patch panels in the MDF as necessary to service all workstation cables plus the required spare count. Provide separate CAT 6A patch panels as required for CAT 6A cables serving wireless access point outlets.
- d. Patch Cables: Panduit UTPSPXX-** or equal where XX is the length in feet and ** is the color. The length shall vary between 3' and 15' and shall be determined by the owner. Colors shall also be determined by the owner. A minimum of five different color patch cables shall be carried for different systems.

2. Required Accessories and Quantities:

- a. Adapter Panels: Panduit FAP6WEIDSC – 6 Port Duplex Multimode SC Adapter Panels.
- b. Fiber Jumpers: Panduit F6D3-3M3Y, 3 meter, Duplex, 50 micron OM3, SC to LC Fiber and ST to LC Fiber Jumper or equal.
- c. Cable Management: Panduit WMPH2E Front/Rear cable manager or Panduit WMPLS Low Profile Cable Manager or equal.
- d. Cable Management Rings and Strain Relief: Panduit WMBV1 21 in. x 5 in. Vertical Manager Ring, Panduit WMBV2 2 in. x 5 in. Vertical Manager Ring and/or Panduit WMSRC1 or WMSRC2 strain relief clips. Provide and install sufficient quantities to conform to attached Drawings.
- e. INSTALLATION: Installation shall be conducted in accordance with manufacturer's recommendations, industry standards, and this specification. Installation includes complete assembly and mounting of the fiber interconnect equipment, dressing the fiber and copper cables, complete assembly and mounting

of the equipment rack, and mounting of the wiring blocks. Equipment shall be mounted in accordance with attached Drawings.

2.06 TESTING AND DOCUMENTATION

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 1. Visually inspect UTP jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
 2. Visually confirm Category 6A marking of outlets, cover plates, outlet/connectors, and patch panels.
 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 4. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Provide test instruments that meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 5. Multi-pair Voice Riser Tests:
 - a. Test each pair of multi-pair voice riser cables for proper polarity; no reversals; no transpositions; continuity; no shorts; no AC voltages; no DC voltages; no opens; and proper numbering at each termination.
 - b. Bring cables and/or pairs not meeting the requirements of the standard into full compliance, at no additional cost to the Owner.
 - c. Document cable testing in accordance with Submittals Article. Provide a table of test results in a 3-ring binder submitted with the as-built Drawings.
 6. Category 6A Data, and Voice UTP Cable Testing:
 - a. Test voice and data jack in each Outlet for Category 6A ANSI/TIA/EIA 568B series compliance, using a Certified Level III testing instrument. Tests shall verify both the integrity of all conductors and correctness of the termination sequence. Tests shall also include length, mutual capacitance, characteristic impedance, attenuation and near-end and far-end crosstalk. Testing shall be performed between modular jacks at the Outlets and the modular jacks at the patch panel field.
 - b. The Communication Systems Installer shall bring cables and/or pairs not meeting the requirements of the standard into full compliance, at no additional cost to the Owner.

- c. Document cable testing in accordance with Submittals Article. Provide a table of test results in a 3-ring binder submitted with the as-built Drawings.
- D. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.

Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
- E. Document data for each measurement. Print data for submittals in a summary report that is formatted similar to Table 10.1 in BICSI TDDM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- F. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- G. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- H. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 GENERAL

- A. Do not install equipment and materials which have not been reviewed by the Architect. Equipment and materials which are installed without the Architect's review or without complying to comments issued with the review shall be removed from the project when so instructed by the Architect. No payment will be made for unapproved or removal if it is ordered removed. The Installer shall be responsible for any ancillary costs incurred because of its removal and the installation of the correct equipment and materials.
- B. Obtain detailed information on installation requirements from the manufacturers of all equipment to be furnished, installed or provided. At the start of construction, check all Contract Documents, including all Drawings and all Sections of the specifications for equipment requiring electrical connections and service and verify electrical characteristics of equipment prior to roughing.
- C. Equipment and systems shall not be installed without first coordinating the location and installation of equipment and systems with the General Contractor and all other Trades.
- D. Any and all material installed or work performed in violation of above requirements shall be re-adjusted and corrected by the Installer without charge.
- E. Refer to all Drawings associated with the project, prior to the installation or roughing-in of the electrical outlets, conduit and equipment, to determine the exact location of all outlets.
- F. After installation, equipment shall be protected to prevent damage during the construction period. Openings in conduits and boxes shall be closed to prevent the entrance of foreign materials.

- G. Home runs indicated are not to be combined or reduced without written consent from the Architect.
- H. All connections to equipment shall be made as required, and in accordance with the approved submittal and setting drawings.
- I. Delivery, Storage and Handling:
 - 1. Deliver, store, protect and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
 - 2. Deliver equipment in individual shipping splits for ease of handling, mount on shipping skids and wrap for protection.
 - 3. Inspect and report concealed damage to carrier within specified time.
 - 4. Store in a clean, dry space. Maintain factory protection or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. Heat enclosures to prevent condensation. Meet the requirements and recommendations of NFPA 70B and the Manufacturer. Location shall be protected to prevent moisture from entering enclosures and material.
 - 5. Handle in accordance with NEMA and the Manufacturer's recommendations and instructions to avoid damaging equipment, installed devices and finish.
 - 6. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passage through restricted areas during transportation, the Manufacturer shall be required to brace the equipment suitably to insure that the tilting does not impair the functional integrity of the equipment.
- J. Site Observation:
 - 1. Site observation visits will be performed randomly during the project by the Architect. Reports will be generated noting observations. Deficiencies noted on the site visit reports shall be corrected. All work shall comply with the Contract Documents, applicable Codes, regulations and local Authorities whether or not a particular deficiency has been noted in a site visit report.
 - 2. Be responsible to notify the Architect ten working days prior to closing in work behind walls, raised access floors, ceilings, etc., so that installed work can be observed prior to being concealed.
 - 3. Areas shall stay accessible until deficiencies are corrected and accepted. Notify the Architect when all deficiencies are corrected. Return reports with items indicated as corrected prior to re-observation by the Architect.
- K. Project Open House:
 - 1. If the Owner elects to have an open house at the end of the project, provide assistance to the Owner. Cooperate and provide manpower to operate and demonstrate systems during the open house as requested by the Owner.

3.02 EQUIPMENT RACKS, CABINETS AND BRACKETS

- A. Securely mount equipment racks, cabinets and wall mounted relay brackets to the building structure. Proper supports such as 3/8 in. lag screws and expansion anchors shall be used. Proper quantity of supports shall be utilized. Drywall screws and other types of supports not specifically

approved to support equipment are specifically prohibited. Submit mounting supports for approval before installation.

- B. Position racks, cabinets, and wall mounted relay brackets in order to have minimum 3 foot clearance for easy access. Equipment racks, cabinets and relay brackets mounted on or against walls shall have 3 foot clearance in front of deepest component. Free standing equipment racks and cabinets shall have 3 foot clearance in front and rear of deepest components. Provide 3 foot clearance between free standing equipment racks or cabinets and any other obstruction to allow access from front to rear of rack or cabinet for maintenance.
- C. The Electrical Contractor shall provide cable tray over each rack and cabinet as required to facilitate a neat and orderly installation of cables and to secure the top of the racks to the structure. Cables shall drop straight down to equipment racks. Cable trays shall be secured at both ends to the structure and connected together as required for a complete contiguous installation. Utilize proper supports to support the cable tray to the building structure as well as the equipment rack and cabinet. Submit mounting supports for approval before installation.
- D. Cable Management: All cables shall enter the wiring closet to within the equipment racks and/or brackets. Secure the bundle(s) to the rack strain relief and wire management behind the patch panels and cross connect block panels. Install horizontal and side-mounted vertical cable management panels and brackets for routing and management of patch cables. Maintain EIA/TIA and BICSI standards on bundling, supporting and bend radii.
- E. Once the cabling system has been installed and terminated, install all active components and surge protected power strips into the racks, cabinets and wall mounted relay brackets.
- F. Surge Protected Outlet Strips: Mount UPS and surge protected outlet strips per Manufacturer's directions. Refer to details on the Drawings for mounting location.

3.03 TERMINATIONS

- A. All copper conductors of every cable shall be completely terminated at both ends.

3.04 CABLE PATHWAYS

- A. Install cables in pathways provided by the Electrical Subcontractor or required under execution part of this Section.
- B. Provide all equipment and cabling for a complete installed operating system. In general, pathways, outlet boxes and grounding are provided by the Electrical Subcontractor.
- C. All pathways provided under this Section shall comply with fill capacities as per Code, EIA/TIA 569 and BICSI.
- D. Cable bending radius shall not be less than minimum required by EIA/TIA and BICSI.
- E. Cabling installed concealed shall be supported from the building structure (e.g. cable trays, J-Hooks, etc.).

- F. Cables shall be installed no closer than 12 inches (305mm) to electrical equipment and wiring. When cables are required to cross power wiring, they shall only do so perpendicular to the power wiring. Telecommunications cabling and power wiring shall only cross each other the minimal number of times as required due to building design limitations.
- G. Clearances: Clearances between cabling and other building systems as required by EIA/TIA 569 and BICSI shall be maintained throughout the building.
- H. All cables shall be installed in a neat and workman-like manner. Cables shall be installed parallel and perpendicular to building elements.
- I. Provide expansion fittings and adequate cable slack at all building expansion joints.
- J. Fire/smoke seal all conduits, raceways, sleeves, slots, etc. where cables pass from one location to another.

3.05 SEALING OF PENETRATIONS AND OPENINGS

- A. Environmental Seals
 - 1. Provide seals on raceways exposed to widely different temperatures, as in refrigerated or cold storage areas. Install seal to prevent circulation of air from warmer to colder sections through the raceway.
 - 2. Provide seals under device plates for outlets on walls between conditioned and non-conditioned spaces.
 - 3. Provide outlet plate gasket seals at all work area outlets on interior and exterior walls.

3.06 SEISMIC SUPPORTS, SUPPLEMENTARY STEEL AND CHANNELS

- A. Provide all supports, supplementary steel and channels required for the proper Seismic installation, mounting and support of all work installed under this Section.
- B. All supports, supplementary steel and channels shall be furnished, installed and secured with all fittings, support rods and appurtenances required for a complete support or mounting system.
- C. Supplementary steel and channels shall be firmly connected to the building construction in a manner approved by the Architect prior to the installation of same. Submit to the Architect, via the General Contractor, the locations proposed for using supplementary steel and channels for the support of equipment, fixtures and raceways. The submittal shall indicate the mounting methods, size and details of the supports, channels and steel; it shall indicate also that weight which the supports, channels and supplementary steel is to carry.
- D. The type and size of the supporting channels and supplementary steel shall be of sufficient strength and size for seismic restraint and to allow only a minimum deflection in conformance with the channel and supplementary steel manufacturer's requirements for loading.
- E. All supplementary steel and channels shall be installed in a neat and workmanlike manner parallel to the walls, floor and ceiling construction. All turns shall be made with 90 degrees and 45 degrees fittings, as required to suit the construction and installation conditions.

- F. All supplementary steel, channels, supports, and fittings, shall be Underwriters' Laboratories, Incorporated, approved, be galvanized steel and be manufactured by Steel City, Unistrut, Power-Strut, T. J. Cope, Chalfant or approved equal.
- G. Provide supports to meet the required Seismic rating as indicated under "Part One" of this Specification.
- H. Provide beam clamps with set screws (C-clamp type).
- I. Work under this Section shall be held in place by Seismic rated methods.
- J. Supporting from the roof decking will not be acceptable.
- K. Provide expansion anchors on masonry units or brick work. Power actuated supports will not be accepted.
- L. Provide stainless steel or corrosion resistant supports in corrosive areas on wet or damp areas.
- M. Support work from the building structure, independent of suspended ceilings, roof deck or other trades work. Where duct work, pipes, pipe racks, type of building construction materials or structural framing members provide obstruction or difficult support means, hanger rods shall be used in association with horizontal sections of steel support channels, in an approved manner.
- N. All work shall be installed in a rigid and satisfactory manner and shall be supported by bar hangers in frame construction or shall be fastened directly with wood screws on wood, bolts with expansion shields on concrete or brick toggle bolts on hollow masonry units, and machine screws or welded threaded studs on metal. Threaded studs of the proper type and holding capacity driven in by a power charge and provided with lock washers and nuts are acceptable for mounting of equipment on solid concrete walls or slabs.
- O. Obtain written permission from the General Contractor allowing use of power activated charges. Use only properly trained and licensed operators.
- P. Do not use power charge driven supports for any work that is to be hung from a horizontal surface without written permission from the Architect.
- Q. Preset inserts of the proper type and holding capacity shall be used in overhead slab construction wherever possible.
- R. Provide lateral supports for work to prevent excessive movement during a seismic event using rods, braces or galvanized or stainless steel cables.
- S. Pendants, supports or hanging rods longer than 12 inches (300mm) shall be laterally braced.
- T. Where installed in damp, wet and areas requiring wash down, all surface mounted panels, boxes, junction boxes, conduit, etc., shall be supported by spacers to provide a clearance between wall and equipment.

3.07 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 26 00 10 "Identification for Electrical Systems."
 - 1. Confirm labeling scheme with the Owner prior to final labeling.
 - 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
- C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.
- E. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
 - 4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
 - b. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- F. Provide preprinted or computer-printed type labels with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:
 - 1. Cable Labels: Use flexible vinyl or polyester that flexes as cables are bent.

3.08 CABLE SUPPORTS

- A. Provide strain relief hardware for backbone cables at each floor level as they pass from one floor to the next.
- B. Provide hook and loop (Velcro) cable wraps at all panels, equipment racks and cabinets. Cable ties are specifically prohibited.
- C. Cable ties for horizontal cables shall be secured with minimum required compression in order to secure the cables properly without impeding the signal transmission rating (geometry) of the cable. Hook and loop (Velcro) cable wraps may be used in lieu of cable ties for copper cables only. Cable-ties are specifically prohibited for fiber optic cables.
- D. When pathways are not provided or specified, provide J-Hook supports from the building structure as required for cable runs to the cable drop location. Maximum distance between supports shall be five feet (1 500mm) depending on the structural elements of the building. Maximum number of cables per support shall be thirty. Provide additional supports as required when cable quantities exceed thirty and to maintain required bending radius of cables. Cables installed exposed or in areas subject to abuse (below 10 feet (3m) above finished floor) or in accessible areas shall be installed in conduit.
- E. All cables shall be supported directly from building structure. Under no circumstance shall cable be installed using cross bracing, plumbing/sprinkler pipes, ceiling systems or any other system that is not a specifically approved method to independently support cables. Cables shall not be allowed to rest on ceiling tiles, duct work, piping, etc. Supports shall be provided as required in order for cables to avoid contact with any other building system. Bundle cables in groups by Room.

3.09 CABLE PROTECTION

- A. Provide bushings in all metal studs and the like where cables will pass through. Bushings shall be of two piece construction with one piece inserted through the opening and the second piece locking it into place. Single piece bushings with locking tabs or friction fit are specifically prohibited.
- B. Cables to be installed in existing enclosed open bays or furred spaces where conduit stubs are not provided shall be protected from chafing or any damage. The Installer shall verify that the warranty shall not be violated before installing any cabling in these locations.
- C. Provide cutting, coring, sleeves and bushings and seal as required at all penetrations.
- D. Fiber optic backbone cables shall be installed in inner duct.
- E. Cables damaged during installation shall not be repaired. They shall be completely replaced with new cable.

3.10 INSTALLATION

- A. All cabling shall be installed in conduit where indicated on plans, or shall be installed open using other methods, approved by architect, such as J-Hooks.

1. Install wiring, per manufacturers recommendations. Use UL listed plenum cable in environmental air spaces including plenum ceilings.
- B. All wiring shall be new and concealed in pipe where exposed.
- C. All conduits and raceways shall have pull strings remaining after cable is pulled.
- D. Impedance and Level Matching:
 1. Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
- E. Control Circuit Wiring:
 1. Install control circuits in accordance with NFPA 70 and as indicated. Provide number of conductors as recommended by system manufacturer to provide control functions indicated or specified.
 2. Make installation in strict accordance with approved manufacturer's drawings and instructions.
 3. The Installer shall provide necessary transient protection on the AC power feed, all station lines leaving or entering the building, and all central office trunks. All protection shall be as recommended by the equipment supplier and referenced to earth ground.
- F. Weatherproofing:
 1. Provide weatherproof enclosures for items to be mounted outdoors or exposed to weather.
- G. Typical Layouts and requirements of the specified systems:
 1. Typical layout:
 - a. Equipment racks and cabinets
 - b. Backbone cabling
 - c. Headend equipment
 2. Typical layout of telecommunications equipment racks and cabinets.
 - a. Each equipment rack and cabinet shall contain the following equipment:
 - 1) Fiber optic patch panel
 - 2) Fiber optic cable management
 - 3) Surge protector power strip
 - 4) Patch panels - Horizontal distribution
 - 5) Horizontal distribution cable management
 - 6) Vertical cable management
 - 7) Patch cords
 - b. Provide space for the installation of network electronics equipment in the equipment racks.
 - c. Furnish and install horizontal cable management between each patch panel (fiber optics, Hub distribution, Horizontal distribution, and telephone distribution).

- d. Furnish and install horizontal distribution patch panels in each wire center with sufficient ports to terminate all modular jacks shown on the drawings plus twenty percent spares. The exact number of modular jacks and horizontal distribution patch panels shall be obtained from the drawings.
- e. Furnish and install all equipment racks and cabinets required to support the aforementioned equipment.
- f. Grounding bars shall be installed under SECTION 26 00 10. Furnish and install the required grounding to ensure that all of the aforementioned equipment is grounded and bonded.

3. Headend

- a. Final terminations from IDC cross connect block panels to telephone equipment and PBX by -Telephone Company and Equipment Installer. Coordinate with Telephone Company and Equipment Installer for final terminations.
- b. Final terminations from the IDC cross connect block panels to the headend equipment shall be provided by the headend equipment installer.
- c. Coordinate with the headend equipment installer and the electrical contractor for:
 - 1) The installation of all the IDC cross connect block panels at the headend equipment. Installation shall be neat in appearance.
 - 2) The final terminations at the headend.

3.11 TRAINING

A. As a minimum, training sessions shall consist of the following:

- 1. General project information and review shall be by the General Foreman or Superintendent of the Trade.
- 2. Specific system training shall be by a Factory Trained Representative.
- 3. Provide a complete review of the project and systems including, but not limited to, the following:
 - a. In a classroom environment review each Record Drawing (use of typicals is acceptable).
 - b. Note equipment layouts, locations and control points.
 - c. Review each system.
 - d. Review system design operation and philosophy.
 - e. Review alarms and necessary responses.
 - f. Review standard troubleshooting techniques for each system.
 - g. Review areas served by equipment.
 - h. Identify color codes used.
 - i. Review features and special functions.
 - j. Review maintenance requirements.
 - k. Review operation and maintenance manuals.
 - l. Respond to questions (record questions and answers).
- 4. After classroom training, walk the entire project, review each equipment room and typical locations. Explain equipment and proper operation.

- B. During the instruction period the Owner and Maintenance Manual shall be used and explained.
- C. The Owner and Maintenance Manual material shall be bound in 3-ring binders and indexed. On the edge of the binder provide a clear see-through plastic holder with a typed card indicating the Project name, the Architect's name, the installer's name and the Volume number (e.g., Vol. No. 1 of 2).
- D. Provide name, address and telephone number of the manufacturer's representative and Service Company for all items supplied so that the source of replacement parts and service can be readily obtained.
 - 1. Include copies of manufacturers and installer's warranties and maintenance contracts and performance bonds properly executed and signed by an authorized representative.
 - 2. Include copies of all test reports and certifications.
- E. Providers of the Broadband Video Distribution System shall provide training as part of their package. This comprehensive training plan shall address the following areas:
 - 1. Training, providers of the Broadband Video Distribution System shall provide (4) hours of training as part of their package, this comprehensive training plan shall address the following areas:
 - a. System Orientation for all involved staff members.
 - b. Small group hands-on training sessions for all media center staff focusing on system-wide hardware and troubleshooting.
 - c. Small group hands-on software training sessions for all media center staff.

3.12 ACCEPTANCE DEMONSTRATIONS

- A. Systems installed under this Section shall be demonstrated to the Owner and Architect. Demonstrations are in addition to necessary testing and training sessions. Notify all parties at least 7 days prior to the scheduled demonstration. Schedule demonstrations, in cooperation with and at times convenient to all parties, so as to not disturb ongoing activities.
- B. Systems shall be tested prior to the demonstrations and each system shall be fully operational and tested prior to arranging the Acceptance Demonstration. Final payments will be withheld until a satisfactory demonstration is provided for all systems indicated or requested.
- C. If the demonstration is not totally complete, performing all functions, features and connections or interfaces with other systems, or if there is a failure during the demonstration, additional demonstrations shall be arranged. Provide and pay for all costs, labor and expenses incurred for all attendees for each additional demonstration required for acceptance and demonstration of complete system operation.
- D. Demonstrations shall be scheduled in ample time to complete all activities prior to final acceptance and Owner occupancy. Demonstrations shall take place at least 30 days prior to the scheduled project completion date and 30 days prior to owner's use and occupancy.

- E. As a minimum, provide demonstrations for systems indicated under "Work Included" under Part One of the Specifications. Provide demonstrations of additional systems as requested by the Owner, or Architect.

3.13 PROJECT OWNER COORDINATION

- A. Prior to Substantial Completion of the project and in ample time to address and resolve any coordination issues, request and arrange meetings between the Owner, Owner's Vendors and Consultants, Architect and General Contractor to discuss the Scope of Work for each system being provided and the interface required for a fully functional and operational system upon project completion. Initial meetings shall be scheduled three months prior to the scheduled Substantial Completion date or as soon as Submittals are submitted and reviewed for projects with shorter schedules.
- B. At these meetings the required interface with the Owner shall be reviewed, requests for information required to complete programming or for coordination shall be presented and system operation and philosophy shall be discussed.
- C. Additional meetings shall be held as requested by any party so that all issues are resolved and with the goal and intent being that all systems are fully operational and functional upon project Substantial Completion and that the responsibility for all components required is clearly established.

3.14 CLEANING UP

- A. Upon completion of all work, and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.
- B. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned and plated surfaces polished.
- C. Repair damage to finish surfaces resulting from work under this Section.
- D. Remove material and equipment from areas of work and storage areas.
- E. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.
- F. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.

3.15 PROJECT CLOSEOUT

- A. Provide close out submittals as required herein and in SECTION 01 78 00 - CLOSEOUT SUBMITTALS including the following close out submittals.
 - 1. Operation and Maintenance Manuals
 - 2. Record Drawings.
 - 3. Test Reports.
 - 4. Extra Materials.

- B. Obtain written receipts of acceptance close out submittals submitted. Receipts shall specifically detail what is being delivered (description, quantity and specification section) and shall be dated and signed by firm delivering materials and by the Owner's Representative.
- C. Telecommunications:
 - 1. Provide fifteen (15 percent) spare patch cables and line cord for each cable length provided.
 - 2. Provide record drawings indicating actual cable routing and cable terminations and all required identifiers. Provide copy mounted in each telecommunications closet and the main cross connect.
 - 3. All sketches, drawings, and charts herein are for the purpose of providing for specifications in a simplified format. Errors and omissions in such does not relieve the Contractor of the responsibility for providing a fully complete, secure and properly operating integrated instructional technology network system suitable for the intended use. Bidders must obtain a complete set of Project Drawings and Specifications to determine the full scope of work. In case of conflict the Project Drawings and Specifications shall prevail.
- D. Construction Waste Management
- E. Comply with Division 01 requirements for construction waste management and recycling.

END OF SECTION 27 00 00

SECTION 275319
EMERGENCY RESPONDER RADIO SIGNAL AMPLIFICATION SYSTEM (BDA SYSTEM)
(Part of Section 260000 Filed Sub-Bid)

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SECTION 275319
EMERGENCY RESPONDER RADIO SIGNAL AMPLIFICATION SYSTEM (BDA SYSTEM)
(Part of Section 260000 Filed Sub-Bid)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

1.02 SUB-SUB BID REQUIREMENTS

- A. SUB-SUB-BID REQUIRING A PARAGRAPH “E” LISTING on the FORM FOR SUB-BID required per M.G.L. Chapter 149 Section 44A to 44L, as amended to date. The Electrical Subcontractor will be responsible for all related building preparation and coordination as required, see specification for additional Paragraph “E” Listing requirements of the BDA System SubContractor, and coordination of responsibilities.
- B. Section 275319 EMERGENCY RESPONDER RADIO SIGNAL AMPLIFICATION SYSTEM (BDA SYSTEM) shall be a Filed Sub-Sub Bid of Section 260000 ELECTRICAL, requiring a Paragraph “E” Listing on the FORM FOR SUB-BID.

1.03 SUMMARY

- A. This specification describes the criteria for deploying an Emergency Responder Radio Signal Amplification System (BDA System). The BDA components specified in this document include: Bi-Directional Amplifiers (BDA), Donor Antennas, Coverage Antennas, Coax Cable, Coax Connectors, Splitters, Combiners and Couplers. These devices shall be used as part of a system, by the BDA integrator, experienced with designing projects for in-building, public safety, 2-way radio systems.
- B. Provide pre-test to determine coverage.
- C. Related Sections include the following:
 - 1. Division 27, Section 270000 COMMUNICATIONS.

1.04 ABBREVIATIONS AND ACRONYMS

- A. ACG: Automatic Gain Control
- B. AHJ: Authority Having Jurisdiction
- C. ATP: Acceptance Test Plan
- D. BDA: Bi-Direction Amplifier

- E. BOM: Bill-of-Material
- F. DAS: Distributed Antenna System
- G. EBS: Educational Broadband Service
- H. ESMR: Enhanced Specialized Mobile Radio
- I. FCC: Federal Communications Commission
- J. GUI: Graphical User Interface
- K. LMR: Land Mobile Radio
- L. MTBF: Mean Time Between Failure
- M. NFPA: National Fire Protection Association
- N. NMS: Network Management System
- O. PSN: Public Safety Network
- P. RoF: Radio-over-Fiber
- Q. RSL: Received Signal Level
- R. SMR: Specialized Mobile Radio
- S. SMS: Short Message Service
- T. SNIR: Signal-to-Noise Interference Ratio
- U. SOW: Statement of Work
- V. VSWR: Voltage Standing Wave Ratio

1.05 DEFINITIONS

- A. Acceptance: Expressed approval by the AHJ and owners representative

1.06 GENERAL DESCRIPTION

- A. The building shall be both pre and post tested for Fire and Police departments radio signal strength. A test shall be scheduled with the Fire and Police Departments. Any expense incurred by the test shall be the responsibility of the BDA System SubContractor.
- B. A site survey to determine the RF signal strength on or near the building grounds to determine the level of amplification necessary to provide clear and reliable radio communications over 95% of the overall area inside the building will be required, and 100% of critical areas as defined in the code is required.

- C. The Fire and Police Departments radio test shall check the signal reception in several locations on the floor area. Signal strength shall be for clear reception throughout the building utilizing the type of hand held radio unit that is used by the Fire and Police Department. Quantity of test locations shall be determined and conducted by the local department representative. Each floor of the building shall be divided into a grid of approximately twenty (20) equal areas. A maximum of one area will be allowed to fail the test per floor. A spot located approximately in the center of a grid area will be selected for the test. Once the spot has been selected, prospecting for a better spot within the grid area will not be permitted. Field strength testing instruments are to be recently calibrated (1 year) and of the frequency selective type incorporating a flexible antenna similar to the ones used on the hand held transceivers.
- D. Required Signal Levels:
 - 1. Signal strength shall be for clear reception throughout the building utilizing hand held radio units of the type(s), which are used by the Fire/Police Department. Signal strength testing shall follow TSB-88 standards using delivered audio quality measurements (DAQ).
 - 2. A minimum signal strength of -95 dBm (DAQ4) shall be available on over 95% of the floor area required to be covered when transmitted from the fire department.
 - 3. A minimum signal strength of -95 dBm (DAQ4) shall be received at the fire department system from over 95% of the floor area required to be covered.
- E. Required Broadcasting Frequency:
 - 1. Frequency to be compatible with Fire, Police Department, and Truro Facilities equipment.
 - 2. The building owner will be responsible for keeping the operational frequencies of the BDA compatible with the Fire and Police Departments radio system.
- F. It is the responsibility of the BDA System SubContractor to coordinate with the Town and provide the required Police and Fire frequencies. Frequencies include Police, Fire, and Truro Facilities.
- G. Emergency Responder Radio Signal Amplification System (BDA System)
 - 1. Provide an in-building radio signal amplification system to provide complete coverage in the building for the public safety agencies as required by the local fire department and other agencies and authorities having jurisdiction. System users shall receive and transmit radio broadcasts from their portable radio units within the building. This shall be accomplished utilizing the following components:
 - a. Bi-Directional Amplifiers (Signal Boosters)
 - b. Plenum rated Coaxial Cable
 - c. Antennas
 - d. Cable taps
 - e. Connectors
 - f. Power dividers
 - g. Other components and interconnecting circuitry as required.
 - 2. The system shall comply with the requirements UL2524 In-Building 2-Way Emergency Radio Communication Enhancement systems, NFPA 72 2013 Edition, NFPA 1221 2016 Edition and IFC 2015, as referenced.
 - 3. The entire system shall meet the requirements of the Fire Department, the Building Department and all other agencies and authorities having jurisdiction (AHJ).

4. The work in this section shall include the responsibility for all permit requirements with the AHJ. Where filings require engineer's signature, documents shall be submitted for his or her review and signature. This responsibility shall include furnishing of required quantities of floor plans, descriptive notes and/or specifications, wiring diagrams, shop drawings and amendment forms.
5. Early completion of the in-building emergency radio communication enhancement system will be required as to permit a Certificate of Occupancy to be obtained in a timely manner
6. Any permits necessary for the installation of the work shall be obtained prior to the commencement of the work. All permit costs and inspection fees shall be included
7. The in-building emergency radio communication enhancement system shall use a UL2524 Listed, NFPA 72, NFPA 1221 and IFC 2018 compliant signal booster or approved equal.

1.07 DESIGN REQUIREMENTS

- A. In-building radio signal amplification systems for emergency responders are an integral component of the life safety equipment of a building or structure. The primary function is to provide reliable emergency responder communications at the required signal strength within the specified areas.
- B. Critical Areas such as emergency command center, fire pump room, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations and similar critical areas shall be provided with 100% floor area radio coverage.
- C. General building areas shall be provided with 95% radio coverage, or as specified by AHJ.
 1. The In-building emergency radio communication enhancement systems must provide the following signal strengths:
 - a. Downlink - Minimum signal strength of -95 dBm throughout the coverage area.
 - b. Uplink - Minimum signal strength of -95 dBm received at the AHJ Radio System.
 - c. OR As otherwise required by the AHJ
 2. The system shall be complete with all components and wiring required for compliance with all applicable codes and regulations, and for its operations described hereinafter.
 3. An approved manufacturer or a qualified and approved vendor shall supply, test and determine locations of components which are required for proper operation as well as to supply, install, test and certify the performance of the complete system. Vendor qualifications must be acceptable to the AHJ.
 4. Design may include iBwave software-simulated radio propagation modeling with heat maps showing predicted signal coverage levels within the building. The iBWave design shall be done by iBWave certified personnel.
 5. All tests shall be conducted, documented, and signed by a person in possession of an FCC General Radio Telephone Operators License. All testing personnel shall be certified and authorized by the signal booster manufacturer in the installation and operation of their equipment. Personnel qualifications must be acceptable to the AHJ.
 6. The system design shall be based on the Radio Solutions, Inc (Norwell, MA) line of Public Safety Signal Boosters UL2524, NFPA 72, NFPA 1221, IFC and FCC certified to establish standards of quality for materials and performance. The naming of a specific manufacturer or a catalog number does not waive any requirement or performance of individual components described in the specifications.

7. Assembly and installation of all components of the Emergency Responder Radio Communication Enhancement System shall comply with all applicable sections of the National Electrical Code.
8. Survivability from attack by fire shall meet requirements of NFPA 72, NFPA 1221, IFC or as required by the local jurisdiction.
9. The system must comply with all applicable sections of the FCC rules. Signal booster shall have FCC certification prior to installation.
10. Antenna isolation shall be maintained between the donor antenna and all inside antennas (D.A.S.) to a minimum of 20dB under all operating conditions

PART 2 - PRODUCTS

2.01 TECHNICAL SPECIFICATIONS AND PERFORMANCE REQUIREMENTS

- A. The system specified shall be based upon Radio Solutions, Inc (Norwell, MA) line of Public Safety UL2524 Listed and NFPA72, NFPA 1221, IFC compliant signal boosters
- B. The signal booster shall be a Class B Public Safety type as designated by the FCC or as required by the AHJ.
- C. The secondary power supplies, battery chargers and system monitoring shall be fully compliant with NFPA 72, NFPA 1221 and IFC. The signal booster shall have both the primary and the secondary power supplies within a waterproof, type-4 approved enclosure.
- D. All signal boosters and other active system components must have FCC certification prior to installation. The equipment FCC ID must be shown on the product datasheets and technical submittals. The ID must also be displayed on the product as required by the FCC.
- E. The signal booster shall be pre-set by the equipment manufacturer for the frequencies specified by the AHJ. Field tuning of RF filters and duplexers is not allowed.
- F. UHF and VHF signal boosters shall be band selective type with a maximum 3dB channel bandwidth of 200KHz ($F_c \pm 100\text{KHz}$) per band. Non-selective wide-band signal boosters shall not be accepted, unless required to cover multiple channels within the same band.
- G. Signal Boosters shall have oscillation suppression circuitry to protect the public safety radio system in case of system malfunction or other causes. The oscillation suppression circuit shall not disable the system operation. Systems that automatically disable the signal booster upon oscillation detection shall not be allowed.
- H. Signal Boosters shall have uplink noise suppression function to eliminate uplink noise while in standby (i.e. no radio transmission from within a building). Systems that produce any measurable level of uplink noise while in standby shall not be allowed.
- I. Signal Booster gain shall be rated at minimum of 80dB and the gain shall be adjustable in a minimum of 30dB range. System gain shall be set and documented at the time of the final system test.
- J. Maximum Propagation delay of the signal booster system shall be the lesser of 14 μs (microseconds) or as specified by AHJ.

- K. The signal booster system shall include built-in automatic supervision of malfunctions of the signal booster and battery system as per NFPA 1221 NFPA 72 and IFC. Non-OEM equipment add-ons and modifications to comply with this specification shall not be allowed.
- L. A dedicated supervised monitoring panel shall be provided within the emergency command center next to the fire alarm panel / annunciator or other location as designated by AHJ to annunciate the status of all signal booster locations. The monitoring panel shall provide visual and labeled indication of the following for each signal booster:
 - 1. Normal AC power
 - 2. Signal booster trouble
 - 3. Antenna Failure
 - 4. Loss of normal AC power
 - 5. Failure of battery charger
 - 6. Low battery capacity
- M. The vendor shall verify the system monitoring requirements and the required annunciator location with the AHJ prior to system installation. System monitoring shall be fully compliant with the AHJ requirements.
- N. Non-OEM External filters, duplexers, power supplies or other non-OEM additions or modifications of the original equipment shall not be allowed.
- O. All signal booster components shall be contained in a type-4 approved and listed waterproof enclosure. All enclosures shall be painted red with external labeling as required by the AHJ.

2.02 INSTALLATION REQUIREMENTS

- A. Installation of all components of the Emergency Responder Communication Enhancement System shall comply with all applicable sections of the National Electrical Code NFPA-70, NFPA-72, NFPA 1221, IFC and / or as required by the local AHJ.
- B. At least 2 independent and reliable power supplies shall be provided as specified in NFPA 72, NFPA 1221 and IFC.
- C. The primary power source shall be supplied from a dedicated twenty (20) ampere branch circuit and comply with NFPA-70 National Electrical Code, NFPA 72 and NFPA 1221 2016 edition.
- D. The signal booster shall be equipped with a secondary source of power. The secondary source of power shall be a battery system with a dedicated battery charger powered by a separate, dedicated twenty (20) ampere branch circuit. The secondary power supply shall power on automatically when the primary power source is lost. The secondary source of power shall be capable of operating the emergency responder radio coverage enhancement system for a period of at least 24 hours. The battery system shall automatically charge in the presence of external power input. Battery charger and all other electronic components must be fully enclosed in a waterproof Type-4 approved enclosure. Batteries shall be enclosed in a separate, vented Type-3R or Type-4 approved enclosure. External UPS (Uninterruptable Power Supplies) are not acceptable.
- E. The signal booster shall be designed to allow continued operation in adverse environmental conditions, such as high temperatures in the event heat from a nearby fire, water spray, voltage fluctuations or other abnormal conditions that may occur during an emergency. Circuits that

intentionally disable the signal booster in such situations (i.e. under/over voltage, over/under current, over/under temperature, etc.) are not acceptable, unless required for FCC regulatory or safety compliance. It is the purpose of this specification to assure the maximum possible level of communications to public safety personnel depending upon the signal booster, even to the extent of damaging the signal booster, as long as some communications benefit can be provided during the emergency.

- F. External UPS (Uninterruptable Power Supplies) are not acceptable
- G. The power supply system design shall be such that neither the failure of the normal power source, the transfer to an emergency source, nor the re-transfer to the normal source shall cause an interruption or change in system status.
- H. The amplifier shall be housed in a room or other suitable space as approved by the Engineer or Architect, or where specifically shown on the drawing.
- I. Radiating cable, if used, shall be run without conduit. All other cable can be run in conduit if required for mechanical protection of the cable, or where specified by the electrical engineer.
- J. RF Coaxial Cable shall be a fire-resistant, low-smoke type, U.L. classified as plenum. The classification shall be clearly marked on the outer surface of the cable regular intervals.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The BDA System SubContractor shall install the BDA in accordance with the integrator's instructions and recommendations.
- B. Installation shall include the delivery, unloading, setting in place, fastening to walls, floors, ceiling, or other structures and where required, penetration fire-stop, interconnecting wiring of the system components, equipment alignment and adjustments, and all other work whether or not expressly required herein which is necessary to result in complete operational system.
- C. All installation practices shall be in accordance with, but not limited to, these specifications and drawings. Installation shall be performed in accordance with the applicable standards, requirements and recommendations of National, State, and Local Authorities having jurisdiction. All distributed antenna cables shall be installed such that the cables are straight as possible.
- D. During the installation, and up to the date of final acceptance, the integrator shall be under obligation to protect his finished and unfinished work against damage and loss. In the event of such damage or loss, he shall replace or repair such work at no cost to the owner.
- E. All equipment shall be properly mounted on equipment racks or walls and secured in place. Wall mounted equipment shall be mounted over a ½" plywood securely attached to the wall.
- F. Cables shall be properly supported with dedicated hangers or brackets. Cable trays shall be used only if they are dedicated low voltage trays and only with approval from the owner.
- G. Fastenings and supports shall be adequate to support their loads with a safety factor of at least three.

EMERGENCY RESPONDER RADIO SIGNAL AMPLIFICATION SYSTEM (BDA SYSTEM)

- H. All boxes, equipment, etc shall be secured plumb, level and square.
- I. In the installation of equipment and cable, consideration shall be given to operational efficiency and overall aesthetic factors. Antennas shall be centered and in-line with other ceiling mounted devices
- J. All cables, regardless of length, shall be marked with cable markers reading “Public Safety Radio”, at regular intervals but not less than every 30 ft. There shall be no unmarked cables at any place in the system. In addition, markings codes at each end of the cables and patch panels shall correspond to codes shown on drawings and/or run sheets.
- K. All cables the integrator installs must be handled in accordance with the manufacturers guidelines. Transmission line cables have minimum bending radius specifications that shall be followed. In the event a cable is kinked or bent excessively during installation that section of cable cannot be used, even if subsequently straightened. The damaged area of the cable shall be removed and a new section installed using correct splice methods. Ultimately the cable must pass the testing and meet the manufacturers requirements
- L. Radio communications cabling shall not be grouped with electrical cabling. It can only share sleeves and raceways with other low voltage data and communications cables.
- M. Connection between cables and other antenna components shall use N-Type premium connectors. No splicing is permitted.
- N. All power dividers shall be securely mounted in place by bolting the mount to a solid surface or securing each by suspension on the cables within 4 inches of each connector termination at the power divider. The transmission lines connecting to the device shall be routed in the shortest possible path.

3.02 GROUNDING PROCEDURE

- A. In order to minimize problems resulting from improper grounding, and to achieve maximum signal-to-noise ratios, the following grounding procedures shall be adhered to:
- B. System Ground: A signal primary “system ground” shall be established for the system. All grounding conductors in that area shall connect to this primary system ground. The system ground shall consist of a copper bar of sufficient size to accommodate all secondary ground conductors. An extension of the ground shall connect to the buildings lightning protection system per the direction of the on-site electrical engineer.
- C. A copper conductor, having a maximum of 0.1 Ohms total resistance, shall connect the primary system ground bar to the primary system ground ring.
- D. Secondary system grounding conductors shall be provided from all racks, radio consoles, and undergrounded radio equipment in each area, to the primary system grounding point for the area. Each of these grounding conductors shall have a maximum of 0.1 Ohms total resistance.
- E. Under no conditions shall the AC neutral conductor, either in the power panel or in receptacle outlets, be used for a BDA system ground.
- F. Radio cable Shields: All radio cable shields shall be grounded at both ends.

- G. General: Because of the great number of possible variations in grounding systems, it shall be the responsibility of the installer to follow good engineering practice, as outlined above, and to deviate from these practices only when necessary to minimize crosstalk and to maximize signal to- noise ratios and reduce interference in the radio systems.

3.03 CABLE AND CONDUIT

- A. Note the following circuitry requirements:
 - 1. Conduit intended for use with the firefighter's communication bi-directional radio amplifier system shall be steel electric metallic tubing (EMT), except as follows:
 - a. It shall be galvanized steel intermediate conduit where mounted within 8'-0" of the floor in mechanical spaces or otherwise exposed to mechanical damage, or where intended for embedment in concrete.
 - b. It shall be galvanized steel intermediate conduit if local authorities prohibit use of EMT.
 - c. It shall be rigid galvanized steel conduit for the power supply to the central equipment and to all outlying equipment cabinets requiring a 120-volt or 120/208- volt supply.
 - 2. Where wires and cables are permitted to be run without conduit, they shall be independently supported from the building structure or ceiling suspension systems at intervals not exceeding four feet on center, utilizing cable supports specifically approved for the purpose. Wires and cables shall not rest on or depend on support from suspended ceiling media (tiles, lath, plaster, as well as splines, runners or bars in the plane of the ceiling), nor shall they be supported from pipes, ducts or conduits. Bundling and/or supporting ties shall be of a type suitable for sue in a ceiling air handling plenum regardless of whether or not installed in a plenum.
 - 3. Cables shall be tagged or labeled at each termination point and in each intermediate junction box, pull box or cabinet through which they pass, as well as intervals not exceeding 50 feet on centers where cables are run without conduit.
 - 4. Comply with applicable building and electrical code requirements for locating and routing circuitry, for installing circuitry, and for fire stopping.
 - 5. The covers of all dedicated junction, pull boxes shall be painted red and labeled "Fire Dept. Radio System". Junction and pull boxes will not be shared with other systems.
 - 6. Cables other than radiating coaxial cables shall be run in conduit where indicated by the Engineer. Where not indicated, cable shall be installed per manufacturer's recommendation. Conduit shall be electric metallic or threaded conduit subject to the restrictions specified elsewhere for light and power circuitry.
 - 7. Radiating coaxial cables shall be run without conduit. Where installed in a plenum type ceiling cable insulation shall be of a fire-resistant low-smoke producing type, with a minimum rating of CATVR. This classification shall be clearly marked on the outer surface of the cable at regular intervals.

3.04 ACCEPTANCE TESTING

- A. Acceptance and Test Procedures
 - 1. Acceptance testing for an in-building radio system is required upon completion of installation.

2. The coverage testing shall be done in accordance with NFPA 72, National Fire Alarm and Signaling Code, 2013 edition, and as required by the local AHJ
3. All tests shall be conducted, documented, and signed by a person in possession of a current FCC General Radio Operator License.
4. All test records along with system diagrams, equipment specifications, user manuals, RF link budget calculations, battery backup calculation and other design data shall be submitted upon completion of the project.

END OF SECTION

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 INTEGRATED ELECTRONIC SECURITY SYSTEM (IESS)
 (Part of Section 26 00 00 Sub-Bid)

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SECTION 280000
INTEGRATED ELECTRONIC SECURITY SYSTEM (IESS)
(Part of Section 26 00 00 Sub-Bid)

PART 1 - GENERAL

1.01 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.
- D. The following definitions apply to the Drawings and Specifications:
 - 1. Furnish: The term "furnish" is used to mean, "supply and deliver to the Project Site, ready for unloading, unpacking, assembly, installation, and similar operations".
 - 2. Install: The term "install" is used to describe operations at the Project Site including actual "unloading, unpacking, assembly, erection, piecing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations".
 - 3. Provide: The term "provide" is used to mean, "furnish and install, complete and ready for the intended use".
 - 4. Installer: An "installer" is the Contractor furnishing and installing the IESS in its entirety. Installers are required to be experienced in the operations they are engaged to perform.
- E. When open-flame or spark producing tools such as blow torches, welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four (24) hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant non-working fire watch where work is being performed until it is completed.

1.02 FILED SUB SUB-BID REQUIREMENTS

- A. Sub bidder's attention is directed to Massachusetts M.G.L. Chapter 149 Section 44F, as amended, which provides in part as follows.
- B. Section 280000 INTEGRATED ELECTRONIC SECURITY SYSTEM shall be a Filed Sub- Sub Bid of Section 260000 ELECTRICAL, requiring a Paragraph "E" Listing on the FORM FOR SUB-BID.

- C. Each sub-bidder shall list in Paragraph E of the "Form for Sub-bids" the name and bid price of each person, firm or corporation performing each class of work or part thereof for which the Section of the Specifications for that sub trade requires such listing, provided that, in the absence of a contrary provision in the Specifications, any sub-bidder may, without listing any bid price, list his own name or part thereof and perform that work with persons on his own payroll, if such sub-bidders, after sub-bid openings, shows to the satisfaction of the Awarding Authority that he does customarily perform such class of work with persons on his own payroll and is qualified to do so. This Section of the Specifications requires that the following classes of work shall be listed in Paragraph E under the conditions indicated herein.
- D. This Section shall be provided by a qualified Systems Contractor.
 - 1. The Systems Contractor shall be DCAM Certified by the state of Massachusetts Division of Capital Asset Management, in the category of: ALARM SYSTEMS.

1.03 SUMMARY

- A. Work described herein shall be interpreted as work to be done by the Integrated Electronic Security System Contractor. Work to be performed by other trades will be referenced to a particular contractor.
- B. The work under this Section includes providing of all material, labor, equipment and supplies and the performance of all operations to provide a complete working Integrated Electronic Security System, as required by the Drawings and details as specified herein. Where the Drawings, Specifications, Codes, Regulations, Laws, or the requirements of the drawings/specifications conflict, provide the higher quality and higher quantity indicated or required and follow the strictest requirement. In general, the work includes, but is not limited to, the following:
 - 1. Systems:
 - a. Electronic Access Control
 - b. IP Based Electronic Surveillance System (CCTV) and Network Video Recording System
 - c. Intrusion Detection Systems.
 - d. Remote Access
 - 2. Equipment Racks and Cabinets.
 - 3. Terminations.
 - 4. Conduit Systems and sleeves will be provided by the Electrical Sub-Contractor.
 - 5. 120VAC Power Requirements will be provided by Electrical Subcontractor.
 - 6. Protection of new and existing work.
 - 7. Record Drawings and Documentation.
 - 8. Staging.
 - 9. Operation and Maintenance Instructions and Manuals for the Section's work.
 - 10. Nameplates, Labels and Tags.
 - 11. Testing and certification.
 - 12. Fireproofing of Penetrations and Openings will be provided by the Electrical Sub-Contractor.
 - 13. Access panels and doors.
 - 14. Coordination with manufacturers, other trades and Owner.
 - 15. Core drilling and cutting will be provided by Electrical Sub-Contractor.
 - 16. Patching will be provided by General Contractor.
 - 17. Testing of all equipment installed.

- C. Provide and maintain in safe adequate condition all staging and scaffolding required for the proper execution of the work of this Section. All staging and scaffolding required for this work shall be provided by the security contractor for the first 8' in height. Staging and scaffolding which is beyond 8' in height shall be provided by the General Contractor including the first 8'.
- D. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.
- E. Service and Preventative Maintenance Program
 - 1. Includes manufactured approved software maintenance agreement (SMA) for the duration of the warranty period.
 - 2. Includes all service and warranty support on entire IESS.
 - 3. Includes quarterly preventative maintenance on entire IESS. See specification for details.
 - 4. Includes a minimum of (1) IESS software upgrade during the warranty period to the latest version of software.
 - 5. All labor must be performed by manufactured certified technicians.

1.04 QUALIFICATIONS

- A. It is the intent of this specification to have a single source of responsibility from either a qualified Systems Integrator or a single qualified installer/systems integrator where the systems integrator provides parts, programming, configuration, testing, and warranty (parts and smarts) and installer is qualified in the installation of the systems. The systems integrator/installer shall provide the Division 280000 scope in its entirety, which will include, but not be limited to; all material, cable, cabling, installation, programming, configuration, testing and warranty. Box conduit and 120 volt provisions are installed by the Electrical Contractor.
- B. The Systems Integrator will be the firm whom is listed as the sub-contractor on the Electrical bid form.
- C. The Systems Integrator shall have experience in the IESS and provide documentation on manufacture letterhead that they are a certified dealer of the IESS platform for a minimum of two (2) years.
- D. The Systems Integrator shall hold and maintain a valid S-License from the State of Massachusetts Department of Public Safety. Individuals employed by S-License holder must obtain a Certificate of Clearance prior to engaging in any work on the Project.
- E. The Systems Integrator shall have a local office with service depot no more than (100) miles from the project site. The local office shall have manufacture trained engineers and technicians who are qualified to provide instructions, routine and emergency maintenance and repairs on all portions of systems. Service staff shall be available for emergency service on a 24-hour basis.
- F. The Systems Integrator shall be experienced in the operations they are engaged to performed.
- G. The Systems Integrator shall be experienced in the operations they are engaged to perform, trained, licensed, and factory certified.
- H. UL Compliance: The system supplied shall be listed by Underwriter's Laboratories. A copy of the UL listing card for the proposed system shall be included with the contractor's submittal.

- I. FCC Approval, the intrusion detection system shall be approved for direct interconnection to the telephone utility under Part 68 of FCC rules and regulations. Provide the FCC registration number of the system being proposed as a part of the submittal process.

1.05 RELATED SECTIONS

- A. Unless otherwise indicated, the following work is not included as part of the systems integrator's responsibilities in this SECTION, except for coordination, and is to be performed by others as indicated:
 1. Surface mounted metal raceway will be provided by Electrical Sub-Contractor.
 2. Empty conduits to accessible point above ceiling or below floor will be provided by Electrical Sub-Contractor.
 3. Floor boxes and poke through devices will be provided by Electrical Sub-Contractor.
 4. Standard device boxes with plaster rings for Integrated Electronic Security System will be provided by Electrical Sub-Contractor.
 5. Interface with public utilities telephone service shall be arranged by the owner's service provider, and coordinated with this systems integrator.
 6. Hardware: SECTION 087111 – DOOR HARDWARE
 7. The installation, operating cost and maintenance of the controlled environmental conditions, for equipment located on site, as required by the manufacturer, NFPA 70B, or as specified in these specifications shall be the responsibility of the Construction Manager.
 8. All required sleeves, J-Hooks, boxes and conduits for a complete and operational system shall be provided by the Electrical Sub-contractor, Electrical Contractor shall provide J-hooks every 5' where cables will be run concealed above accessible ceilings.

1.06 DEFINITIONS

- A. Integrator: The "Integrator" is the IESS (Integrated Electronic Safety and Security) Systems Integrator who uses their own employees for performance of all construction activity related to their specified responsibilities, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform and the "Installers" must be certified, experienced and qualified to provide, install, program, troubleshoot, train, warrant and service all the systems in this section in their entirety.
- B. EIA - Electronics Industries Association
- C. TIA - Telecommunications Industry Association
- D. ANSI - American National Standards Institute
- E. TSB - Technical Systems Bulletin (EIA/TIA)
- F. SP - Standards Proposal (EIA/TIA)
- G. IESS – Integrated Electronic Security System

1.07 REFERENCES

- A. Comply with applicable requirements of the following standards and those others referenced in their Section as most recently amended.
- B. EIA/TIA Building Telecommunications Wiring Standards:
 - 1. No. 568B Series - Telecommunications Wiring Standards
 - 2. No. 569A - Telecommunications Pathways and Spaces
 - 3. No. 606 - The Administration Standard for the Telecommunications Infrastructure
 - 4. No. 607 - Grounding/Bonding
- C. Materials and workmanship of the Integrated Security System shall conform to the latest issue of all industry standards, publications, or regulations referenced in this section and with the following applicable.
 - 1. Commonwealth of Massachusetts Building Code
 - 2. Massachusetts Electric Code, 2023 Edition
 - 3. State Department of Public Safety
 - 4. NFPA 101 "Life Safety Code"
 - 5. NFPA 72 National Fire Alarm Code
 - 6. NFPA Standards
 - 7. Standards of the Underwriters Laboratories (UL)
 - 8. Occupational Safety and Health Act (OSHA)
 - 9. Americans with Disabilities Act (ADA)
 - 10. Town of Truro

1.08 SYSTEM DESCRIPTION

- A. Provide a complete working Integrated Electronic Safety and Security System as required by the Drawings and details and as specified herein. The complete system shall be provided and Integrated by security system and life safety service provider.

1.09 PERFORMANCE REQUIREMENTS

- A. Include GENERAL CONDITIONS, SUPPLEMENTARY GENERAL CONDITIONS and applicable parts of Division 01 as part of this Section.
- B. Examine all Project Specifications and Drawings for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.

1.10 INTERPRETATION OF DRAWINGS

- A. All work indicated on the Drawings is intended to be correct to scale, but figures dimensions and detailed Drawings are to be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of raceways and methods of running them are indicated, but it is not intended to show every offset and fitting, nor every structural difficulty that may be encountered.

- B. Locations indicated on the Drawings are approximate and it is intended that all equipment shall be located in accordance with the general and detail Drawings of the construction proper. Coordinate the location, mounting heights and routing of cabling work with other trade's requirements and with field conditions, city electrician and engineer.
- C. All measurements shall be taken at the building before fabrication commences.
- D. Schematic diagrams shown on the Drawings indicate the required functions. Standard diagrams of the manufacturer may be used for the functions indicated without exact adherence to the Schematic Drawings shown. Work required for such deviations shall be provided.
- E. Items referred to in singular number in Contract Drawings shall be provided in quantities necessary to complete work.
- F. The right is reserved to make changes in locations of work prior to rough-in at no additional cost.
- G. Where Drawings or Specifications conflict or are unclear, advise the Architect, in writing, before Award of Contract. Otherwise, interpretations of Contract Documents by the Architect shall be final, and no additional compensation shall be permitted due to discrepancies or unclarities resolved according to the Architect's interpretation.
- H. It is the intent of these Contract Documents to have systems and components that are fully complete and operational and fully suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem, or the routing of a component. In cases such as this, where the Installer has failed to notify the Architect, in writing, of the situation prior to Contract Award, the Installer shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in workmanlike manner either concealed or exposed per the design intent.

1.11 MATERIAL AND EQUIPMENT STANDARDS

- A. Materials shall be new, unused, of recent manufacture, not previously installed, full weight, standard, the best quality of its kind and acceptable to the Architect.
- B. Provide NRTL listed or labeled products whenever there are NRTL standards, listings or labeling available for that product category.
- C. The Specifications or notes and description following a catalog number is basically to identify the item, but may also call for accessories, options or modifications which are not indicated in the catalog number.
- D. Provide products of one manufacturer for each classification of equipment.

1.12 WARRANTY

- A. Provide one (1) year Warranty, warranty shall start at time of substantial completion. Any failure due to defective material, equipment, installation or workmanship which may develop,

shall be corrected at no expense to the Owner including all materials, labor, travel, expenses, system diagnostics and damage to areas, materials and other systems resulting from such failures.

- B. Manufacturers shall provide replacement warranties for material and equipment furnished under this Section. Such warranties shall be in addition to and not in lieu of all liabilities which the Manufacturer and the Installer may have by law or by provisions of the Contract Documents.
- C. Include copies of all warranties, maintenance contracts and training contracts or performance bonds in the Operation and Maintenance Manuals.
- D. Refer to SECTION 017700 – CLOSEOUT PROCEDURES.

1.13 MAINTENANCE

- A. Provide installers maintenance contract, for a period equal to warranty.

1.14 CERTIFICATES OF APPROVAL

- A. Upon completion of all work, and as a condition to receiving payment at Substantial Completion, furnish to the Architect the following original signed certificates and include copies of these certificates as part of the Operation and Maintenance manuals: (Provide 3 copies of O & M Manuals).
 - 1. Certification from the manufacturers authorized representative stating that authorized factory engineers have inspected and tested the operation of their respective equipment and found same to be installed in accordance with the manufacturer's requirements, all requirements for manufacturer's warranties are complied with, and equipment are within factory tolerances. This certification shall be provided for each piece of major equipment and for all complete systems. Provide certificate for additional items requested by the Architect.
 - 2. Certificates of inspection, letters or notices from the appropriate governmental authorized inspection authorities stating that all portions of the work (indicate trade and responsibility) have been inspected and are installed in conformance with the applicable codes, laws, ordinances and referenced standards. If non-conformance notices are received, include the re-inspection certificate, letter of explanation, etc. as required to indicate complete conformance. Provide written evidence of all exceptions or variances given by the AHJ.
 - 3. Certificate from the installing firm responsible for the work (indicate trade and responsibility) signed by an authorized Officer of the firm and the Foreman or Project Manager in charge, indicating trade license numbers and stating that to the best of the signer's knowledge and belief that the project (indicate project name and address) has been installed in compliance with the Contract Drawings, Specifications and Addenda, and all applicable codes, laws, ordinances and referenced standards. Where sub-contractors perform a portion of the work of this Section include certificates from them.

1.15 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Give detailed instructions, prior to the Substantial Completion of the work, to the responsible personnel designated by the Owner in the operation and maintenance of all work installed under this Section. A letter with two copies containing the name of the person or persons to whom the instructions were given and the dates of the instruction period shall be submitted to the Architect at the completion of the project.
- B. Prepare three sets of Owner and Maintenance containing Manufacturer's catalogs, other similar data including the necessary photographic equipment cuts, wiring diagrams and final reviewed Shop Drawings and Product Data covering all equipment and devices furnished or installed under this Section. These manuals shall provide complete instructions for the proper operation and use of the equipment together with instructions for lubrication and periodic maintenance and for trouble shooting. Operating instructions shall be specific for each system and shall include copies of posted specific instructions. This manual shall contain only that information which specifically applies to this project and all unrelated material shall be deleted or clearly crossed out.
- C. Submit a valid certificate of completion of installation and service training on the latest up-to-date version of the manufacturer's equipment being provided from the security system (or systems) manufacturer (s) for at least two (2) present employees of the installer
- D. Include copies of all test reports and certifications.
- E. Refer to SECTION 017700 – CLOSEOUT PROCEDURES and SECTION 017823 – OPERATION AND MAINTENANCE DATA.

1.16 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Diagrams for cable management system.
 - 2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
 - 3. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
 - a. Workstation outlets, jacks, and jack assemblies.
 - b. Patch cords.
 - c. Patch panels.
 - d. Camera locations, labels, and wiring.
 - e. Card reader locations, labels, and wiring.
 - f. Rack elevation and all equipment.
 - g. Power supplies and wiring.
 - h. Access control devices and wiring.
 - i. Intrusion system one-line diagram.

4. Cable Administration Drawings: As specified in "Identification" Article.
 5. Battery and charger calculations for central station, workstations, and controllers.
- C. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.
- D. Other Action Submittals:
1. Project planning documents as specified in Part 3.
- E. Field quality-control reports.
- F. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Operational Description and Procedures.
 2. Troubleshooting and Routine Test Procedures.
 3. Wiring Diagrams, Tables, Schematics.
 4. Provisional Matrix.

1.17 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
1. Cable installer must have on staff a registered communication distribution designer certified by Building Industry Consulting Service International.
- B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70, "National Electrical Code."
- E. Comply with SIA DC-01, SIA DC-03 and SIA DC-07.

1.18 HOISTING EQUIPMENT AND MACHINERY

- A. Unless otherwise specified, all hoisting and rigging equipment and machinery required for the proper and expeditious prosecution and progress of the Work of this Section shall be furnished, installed, operated and maintained in safe condition by the General Contractor, as specified under Section 015000 – TEMPORARY FACILITIES AND CONTROLS.

1.19 STAGING AND SCAFFOLDING

- A. Unless otherwise specified, the General Contractor shall provide all lifts and man-lifts, and furnish, erect and maintain in safe condition, all staging and scaffolding over 8 ft. in height,

including the initial 8 ft. in height, as needed for proper execution of the work of this Section. Staging and scaffolding shall be of adequate design, erected and removed by experienced stage builders having all accident prevention devices required by Federal, state and local laws.

1. The security contractor shall be responsible for his own scaffolding 8 ft. and under, as specified under Section 015000 – TEMPORARY FACILITIES AND CONTROLS.

1.20 COMMISSIONING REQUIREMENTS

- A. An independent Commissioning Agent (CxA) will be retained for this project. The commissioning process will be implemented in accordance with industry standard commissioning protocols and procedures.
- B. Complete installation and startup checks and functional tests according to Commissioning specifications.
- C. Operational Test: After security system has been started to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start-up procedure.
- D. Verify that equipment is installed and commissioned as per requirements of commissioning specifications manufacturers written instructions/requirements.
- E. Inform Commissioning Agent at least one week prior to startup and/or programming of security system.
- F. Refer to Section 018123 – General Commissioning Requirements.

1.21 ALTERNATES

- A. Refer to Section 012300 for Alternates affecting this section.
 1. Add Alternate No. 1: Added Connector Road to DPW/Police
 - a. Base Bid: Graded landscaped area as shown on the Civil Drawings.
 - b. Alternate: Furnish a cost to add the new connector road as shown on the Civil Drawings. Refer to specification Section 321610 “Curbing.”

PART 2 - PRODUCTS

2.01 SYSTEM CABLING

- A. Provide and terminate all cabling per manufacturers recommendations for a completely operational system as specified.
- B. CCTV System Cabling, provide & terminate all cabling as required for a completely operational CCTV System as required by equipment manufacturer.
 1. CCTV Camera Cabling:
 - a. CAT 6A cabling shall be provided for each CCTV camera location.

- b. Provide CAT 6A patch cabling as required between patch panels and POE switches at
 - c. each IDF/MDF location and at camera locations.
 - d. Power cabling for exterior devices shall be 12 gauge 2 conductor, provide applicable gauge per applicable distances.
 - e. Provide all line cords as required, field measured for proper length.
 - f. Provide any additional cabling as required per manufacturer's specifications.
 2. Telephone Line interface; provide and terminate a Cat 6A cable between security system headend and the MDF/Demarc.
- C. Intrusion Alarm System Cabling, provide & terminate all cabling as required for a completely operational Intrusion Alarm System as required by equipment manufacturer.
 1. Key Pad: The control station shall be connected to the control/communicator with #18 AWG, unshielded, 4-wire cable and have a maximum of 1000 feet between the control/communicator and the control station.
 2. The Electrical Sub-Contractor shall provide 120VAC duplex outlet at the Intrusion Alarm System Controller location.
 3. Multiplex Loops: Provide #18 AWG four conductor cable for loops up to 2000 feet, provide #18 AWG four conductor cable for loops up to 5000 feet. Do not use twisted pair or shielded cable for multiplex bus wiring loops. Cable shall be as required by the equipment supplier.
 4. Audible Devices, provide a minimum #14 AWG four conductor cable.
 5. Telephone Line interface, provide and terminate a Cat 6A cable between the Intrusion Alarm System Controller and cellular communication.
 6. Cellular Alarm Transmission:
 - a. Provide a cellular RF communicator equal to Starlink #SLE-LTEV-CFB and all programming antennae, battery back-up and testing to connect to a UL listed central station. Cellular communicator shall report Contract ID to report by device. Provide one year of monitoring by a UL listed central station.
- D. Cabling for Access Control System, provide & terminate all cabling as required for a completely operational Access Control System as required by equipment manufacturer.
 1. EL = Door Lock Device; provide & terminate cabling between EL and associated Power Supply and between Power Supply and associated ACC. Electrical Sub- contractor shall confirm power supply location with installer. Electrical Sub-contractor shall provide 120VAC outlet and power supply backbox at power supply location. EL furnished and installed by door hardware. EL may be an Electronic Door Strike, Magnetic Door Lock, etc., see Architect for details.
 2. CR/KP = Door Reader Device; provide CR/KP, provide and terminate cabling to associated ACC. The cable requirements of the card reader shall be a minimum five.
 3. (5) conductor, 22 AWG, stranded cable with overall shield (for a Wiegand protocol interface). A six (6) conductor cable is required when controlling the red and green LED individually. A seven (7) conductor cable is required when both the red and green LED's are controlled by the Host. A 22 AWG twisted pair, shielded, stranded cable is required for use of the tamper switch. The card reader shall be provided with a 10 wire pigtail connector.
 4. ALM = Alarm Line Module; provide ALM, provide & terminate cabling to associated Door Contact, and ACC. ALM mounts within J-Box at door location.
 5. DC = Door Contacts (recessed in door/frame); DC furnished, installed and wired by

- systems integrator, provide & terminate cabling to associated ALM (Alarm Line Module).
- 6. ACC = Access Control System Controller.
- 7. ACS = PC & Monitor for Access Control System.
- 8. Fire Alarm System interface.
 - a. Provide and terminate cabling between applicable electronic door lock power supplies and the fire alarm system headend. Terminations to fire alarm control panel by fire alarm contractor.
 - b. Provide and terminate cabling between access control system headend and the fire alarm system headend. Terminations to fire alarm control panel by fire alarm contractor.
 - c. Cat 6A cable between the Access Control System and the MDF/Demarc.
- E. ACM Recommended Cables:
 - 1. Specific rs-485 cables:
 - a. PVC-Belden 9841 (1 pair), 9842 (2 pairs), 9844 all 24 AWG shielded
 - b. Plenum – Belden 82841 (1 pair), 82842 (2 pairs), 89841 (1 pair), 89842 (2 pairs) all 24 AWG shielded.
 - c. PVC – Belden 3105A (1 pair), 3107A (2 pairs), 3108A (3 pairs) all 22 AWG shielded (longer distances)
 - 2. For Readers > Panel:
 - a. Specific rs-232 cable
 - b. PVC – Belden 9536 (6 wires) 24 AWG shielded
 - c. PVC – Belden 9942 (6 wires) 22 AWG shielded (longer distances)
 - 3. For Locks:
 - a. Control Cables
 - 1) PVC – Belden 8719 (1 pair) 16 AWG shielded.
 - 2) Plenum – Belden 8471 (1 pair) 16 AWG unshielded (longer distances)
 - 3) PVC – 8461 (1 pair) 18 AWG unshielded
 - 4) Plenum – Belden 89740 (1 pair) 18 AWG unshielded
 - 4. For Inputs:
 - a. Control Cables
 - 1) PVC – Belden 8451 (1 pair) 22 AWG shielded
 - 2) PVC – Belden 8729 (2 pairs) 22 AWG shielded
 - 3) PVC – Belden 9418 (2 pairs) 18 AWG shielded
 - 4) PVC – Belden 9302 (2 pairs) 22 AWG shielded
 - 5) PVC – Belden 9305 (4 pairs) 22 AWG shielded
 - 6) PVC – Belden 9306 (6 pairs) 22 AWG shielded
 - 7) PVC – Belden 9309 (9 pairs) 22 AWG shielded
 - 8) Plenum – Belden 89418 (2 pairs) 18 AWG shielded
 - 9) Plenum – Belden 82777 (3 pairs) 22 AWG shielded, 82778 (6 pairs) 22 AWG shielded

2.02 EQUIPMENT CABINETS

- A. Provide equipment cabinets to house all security equipment, communication equipment, telephone/data equipment, and audio visual equipment. Racks shall be located as shown on the drawings.
- B. Manufacturer: Provide products meeting the requirements of the Drawings and Specifications from one of the following Manufacturers or equal:

1. Chatsworth, Great Lakes.
2. Winsted
3. Lowell
4. Or equal.

2.03 SURGE PROTECTED POWER STRIP

- A. Manufacturer: Provide products meeting the requirements of the Drawings and Specifications from one of the following Manufacturers:
 1. Wiremold Sentrex, TrippLite, S.L. Weber or equal.
- B. Surge protected power strip shall be rack mount type with 10 ft. cord.
- C. Surge protected power strip with six NEMA 5-15R outlets 15 amp capacity, 120 volts, UL 1449 listed, maximum surge current of 33,000 amps, clamping voltage of 260 volts, maximum 5 picosecond response time, resettable overload circuit breaker, surge suppression warning light, surge protection for line to neutral, line to ground, neutral to ground, EMI/RFI filters. One required for each load up to 1200 watts (total of individual equipment loads).

2.04 CABLE SUPPORTS

- A. Manufacturer: Provide products meeting the requirements of the Drawings and Specifications from one of the following manufacturer's:

J-Hooks:	Caddy, Chatsworth, Mono-System, or equal.
Hook and Loop Fasteners:	Chatsworth, Ortronics, Siemons, or equal.
Cable Ties:	DEK, Panduit, Amp, 3M, T&B, or equal.
Beam Clamps:	Burndy, Minerallac, Kindorff, Steel City, OZ/Gedney, or euqal.
Split Mesh Strain Reliefs (Kellums):	Hubbell, Woodhead, or equal.
- B. J-Hooks shall be sized to correctly support the number of cables, which pass through them. Under no circumstances shall cable quantity exceed 50 in any given support. Fill capacity shall be as required by code for conduit. That is to say that every J-Hook shall have a maximum of 40 percent fill capacity. Install additional supports as required.
- C. Hook and loop fasteners shall be designed for their specific application. For example, if a hook and loop fastener is used to support cables to a rack, it shall have a grommeted outlet for use with a 10-32 rack mounting screw.
- D. Cable-ties shall be correctly sized to support the quantity and types of cables installed.
- E. Beam clamps shall be steel with threaded bolt type closure. Spring steel or "quickclip" type clamps are prohibited.
- F. Split mesh strain reliefs shall be properly sized for each cable that they support. Only one cable shall be installed in each split mesh strain relief.

2.05 BONDING AND GROUNDING JUMPER CABLE

- A. Manufacturer: Provide products meeting the requirements of the Drawings and Specifications from one of the following manufacturers:
 - 1. Belden (No. 8669) or equal.
- B. Jumper cable shall be hollow braided, 60 amp capacity, copper.
- C. Provide equal conduct of as described in "B" above for aluminum equipment.
- D. Jumpers shall have compression or exothermic type terminals on both ends of cables. Terminals shall be compatible with jumper cable material and equipment material in order to not have any degenerative reaction.

2.06 UNSHIELDED TWISTED PAIR (UTP) CABLING SYSTEMS

- A. Provide all security data cabling as specified herein and shown on the Security drawings. The security cable and jacks shall be red in color.
- B. Manufacturer: Provide products meeting the requirements of the Drawings and Specifications from one of the following manufacturer's or equal:
 - Wire and Cable: Belden, Berk-Tek, CommScope, General Cable, Mohawk, or equal.
 - Patch Panels: Hubbell, Ortronics, Panduit, or equal
 - Patch Cables: Shall be provided by patch panel, Outlet or wire and cable manufacturer.
 - Cable Management: Shall be provided by patch panel manufacturer.

NOTE: Each of the products listed above shall be provided by a single manufacturer.
- C. UTP Pin/pair Termination Assignment
 - 1. The UTP cabling systems shall have EIA/TIA 568B Series standard pin/pair termination assignment. All conductors provided shall be properly and consistently terminated at both ends throughout the entire systems.
- D. Horizontal Cable –Security Data
 - 1. Provide & terminate cabling from each camera location to applicable IDF/MDF/Low Voltage rack locations.
 - 2. Data Cable shall be TIA/EIA-568-B.2-1 Category 6A Unshielded Twisted Pair (UTP) as specified.
 - a. Cable shall meet or exceed the approved TIA/EIA-568-B.2-1 Category 6A Unshielded Twisted Pair (UTP) cable standard for 24AWG four pair Category 6A cable.
 - b. Acceptable equal cables shall be General Cable Command LINX 6; and GenSPEED 6000 Category 6A cables.
 - c. Plenum rated cable - GENERAL CONTRACTORP rated jacket for Plenum applications.

E. Cable Management

1. Each equipment rack and equipment cabinet shall have cable management panels with horizontal and vertical brackets.
 - a. Cable management shall be EIA 19 inch (518mm) rack mounted 3.5 inch (88mm) high panel with horizontal and vertical patch cable, distribution rings, or approved equivalent and shall be provided above and below each patch panel in the equipment rack.
 - b. Equipment rack cable management shall be furnished by patch panel manufacturer.
 - c. Cable management for high density, IDC Type cross-connect block panels shall be distribution rings integral to the panel or approved equivalent. Cable management shall be provided above and below each cross connect block in the equipment rack.

F. Modular Jacks

1. Jacks shall be TIA/EIA Category 6A (UL Category 6A) with printed circuit board technology and integral board mounted, color-coded, high density, IDC type terminations. Provide 8 position modular jacks. Keyed jacks are not allowed. Jacks shall be able to withstand at least a minimum of 2000 mating cycles without any transmission degradation.
2. Modular jacks color shall be red.
3. Each 8-position modular jack shall have color-coded icons.
4. Modular jacks that allow pre-connectorized cables to be connected to the jacks are specifically prohibited. Cables shall have single point IDC Type connection to the jacks only.
5. Jack modules shall be flame retardant thermoplastic with integral cable strain relief. Color shall match faceplate.

G. Data Patch Panels for Security

1. Patch panels shall be EIA nineteen inch (518mm), rack mounted, TIA/EIA Category 6A, UL Category 6A type patch panels with integral printed circuit board, color-coded, high density, IDC type terminations and 8 position modular jacks. Keyed jacks are not allowed. Jacks shall be able to withstand at least a minimum of 2000 mating cycles without any transmission degradation.
2. Provide high density rack mounted patch panels.
3. Modular Jacks that allow pre-connectorized cables to be connected to the jacks are specifically prohibited. Cables shall have single point IDC type connection to the jacks only.
4. Each port shall have color-coded identification label. Continuous label strips for multiple in-line ports are acceptable. Silk screened identifiers "1" through "96" are acceptable.
5. Patch panel shall have horizontal strain relief bar on mounted rear.
6. Data Port Labeling Standard
 - a. <Closet>-<Patch Panel>-<Cable Purpose><Patch Panel Port Number>
For Example: 3330-B-D43, This signifies that IDF Room 3330 Panel B on Data Patch Panel port 43

H. Patch Cables and Line Cords

1. Patch cables and line cords shall be factory pre-connectorized, TIA/EIA Category 6A (UL Category 6A), 4 UTP, 8-position modular jack, stranded conductors. Patch cables and line cords shall be able to withstand at least a minimum of 2000 jack mating cycles without

any transmission degradation.

- I. Cross Connect Cabling
 1. Cross-connect cabling shall be NRTL certified that it meets or exceeds the TIA/EIA UL category rating of the system installed.

2.07 ELECTRONIC ACCESS CONTROL SYSTEM

- A. Access Control/Security Management System
 1. Manufacturer:
 - a. Lenel/S2 (Basis of Design)
 - b. Genetec
 - c. Avigilon
 - d. Or Equal
- B. SUMMARY
 1. Section includes the S2 Security Corporation Security and Database Management System (SMS) consisting of computer hardware, software, and associated licensing and equipment for monitoring, recording, and managing Electronic Access Control System (EACS) and Integrated Systems (IS) data and functionality.
 2. The SMS shall meet the requirements of business and government access control systems. The system shall monitor and control facility access, and shall perform alarm monitoring, camera and video monitoring (when integrated with a compatible integrated Video Monitoring System), communications loss monitoring, and temperature monitoring. The system shall also maintain a database of system activity, personnel access control information, and system user passwords and user role permissions. The system shall be controlled from a web browser and require no software installation or client licenses. The system shall provide control and access to users on Local Area Networks (LAN), Wide Area Networks (WAN), wireless networks, and the Internet. The system shall provide email and/or text message alerts for all alarm conditions and threats.
 3. The SMS includes the following sub-components:
 - a. Operating Systems (OS) software and firmware
 - b. Application Software
 - c. Database Software
 - d. Network connected Security Management Servers
 - e. Network connected field level panels
 4. The SMS shall be integrated with monitoring and control systems specified in the following specification sections:
 - a. Division 280000 VMS, and intrusion sections
 - b. Division 260000 Fire alarm and lighting control systems
 - c. Division 270000 Public address system
- C. RELATED DOCUMENTS
 1. Drawings and general provisions of the Contract, including:
 - a. Drawings:
 - 1) E500, E501
 2. Related Specification Sections:
 - a. Division 260000
 - b. Division 270000

D. DEFINITIONS

1. API: Application Programming Interface
2. AVI: Audio Video Interleave
3. CA: Certificate Authority
4. CAC: Common Access Card
5. CE: European Union Conformity
6. CPU: Central Processing Unit
7. CSV: Comma Separated Values
8. DNS: Domain Name Server
9. DSM: Door Status Monitor
10. DVR: Digital Video Recorder
11. EACS: Electronic Access Control System
12. FCC: Federal Communications Commission
13. FIPS: Federal Information Processing Standard
14. FIFO: First In – First Out
15. FTP: File Transfer Protocol
16. FRAC: First Responder Authentication Credential
17. GB: Gigabyte
18. GSOC: Global Security Operations Center
19. HA: High Availability
20. HTML: Hypertext Markup Language
21. H.264: Video Compression Standard
22. I2C: Inter-Integrated Circuit
23. IEEE: Institute of Electrical and Electronics Engineers
24. I/O: Input / Output
25. IP: Internet Protocol
26. IS: Integrated System
27. JPEG: Joint Photographic Experts Group
28. LAN: Local Area Network
29. LDAP: Lightweight Directory Access Protocol
30. MB: Megabyte
31. MJPEG: Motion JPEG
32. MSATA: Mini-Serial Advanced Technology Attachment
33. MSP: Mobile Security Professional
34. MTBF: Mean-Time Between Failure
35. NAS: Network Attached Storage
36. NAT: Network Address Translation
37. NBAPI: NetBox Application Programming Interface
38. NECA: National Electric Code Association
39. NFPA: National Fire Protection Association
40. NVR: Network Video Recorder
41. ODBC: Open Database Connectivity
42. OS: Operating System
43. OVID: Open Video Integration Driver
44. PDF: Portable Document Format
45. PIN: Personal Identification Number
46. PIV: Personal Identity Verification
47. PoE: Power over Ethernet
48. PTZ: Pan-Tilt-Zoom
49. RAID: Redundant Array of Independent Disks
50. RAM: Random Access Memory

- 51. REX: Request to Exit
- 52. RFID: Radio Frequency Identification
- 53. RoHS: Restriction of Hazardous Substances
- 54. ROM: Read Only Memory
- 55. RU: Rack Unit
- 56. SFTP: Secure File Transfer Protocol
- 57. SHA: Secure Hash Algorithm
- 58. SIO: Serial Input / Output
- 59. SLA: Sealed Lead-Acid
- 60. SMS: Security Management System or Short Message Service (text messaging)
- 61. SSL: Secure Sockets Layer
- 62. SUSP: Software Upgrade and Support Plan
- 63. TCP: Transmission control protocol - connects hosts on the Internet
- 64. TIA: Telecommunications Industry Association
- 65. TLS: Transport Layer Security
- 66. TWIC: Transportation Worker Identification Credential
- 67. UI: User Interface
- 68. UPS: Uninterruptible Power Supply
- 69. UTP: Unshielded Twisted Pair
- 70. VMS: Video Management System
- 71. WAN: Wide Area Network
- 72. Wi-Fi: Wireless Network

E. PERFORMANCE REQUIREMENTS

- 1. The S2 SMS shall be certified to meet the following standards:
 - a. ISO 9000
 - b. System shall be RoHS (Restriction of Hazardous Substances) compliant and meet proposed amendments to the reduction of toxic substances in manufacturing as stated in the Environmental Design of Electrical Equipment Act (EDEE)
 - c. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency and marked for intended location and application
 - d. Installation shall comply with NECA 1-2010 "Standard Practice of Good Workmanship in Electrical Construction"
 - e. Installation shall comply with NEC/NFPA 70E "Standard for Electrical Safety in the Workplace"
 - f. Electronic data exchange between Video Surveillance System and an Access Control System shall comply with SIA TVAC
 - g. Installation shall comply with FCC CFR 47 Part 15 Class A "Telecommunications, Radio Frequency, Digital Device Emission"
 - h. Installation shall comply with federal, state, and local codes and Authority Having Jurisdiction (AHJ)

F. ACTION SUBMITTALS

- 1. Product Data: Provide details and technical specifications for each product indicated. Include physical dimensions, features, performance, electrical characteristics, ratings, software versions, and operating system details.
- 2. Shop Drawings: Include system line diagrams, equipment locations, installation details, and system integration plans.
- 3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

4. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types, quantities, and sizes.
5. Plans and Elevations: Dimensioned plans and elevations of equipment racks, enclosures, and conduit interconnections, including access and workspace requirements.
6. Data Calculations: Provide data bandwidth and storage calculations, including data backup and archive configuration details meeting the minimum project requirements as described herein.
7. Power and Heat Load Calculations: Provide power and heat load calculations for all hardware, including UPS capacity calculations.
8. Wiring Diagrams: For power and signal wiring.
9. Equipment and Software List: Include every piece of equipment and software by product/model name and/or number, manufacturer, serial number, revision number, location, and date of original installation. If factory and/or bench testing regimens are required by the project plan, add pretesting record of each piece of equipment and software, listing name of person testing, date of test, and adjustments made.

G. INFORMATIONAL SUBMITTALS

1. ISO9000 Listing Certificates
2. CE and FCC Compliance Certificates:
3. Field quality-control reports
4. Current S2 Security Integrator Certification Letter
5. Current S2 Security Training Certificates (listing expiration dates) for two (2) technicians from the supporting office
6. Warranty: Software support and warranty information for all components, including Service Level Agreement (SLA) details, and duration of agreement from date of system acceptance by Owner
7. Product data sheets for system components highlighted to indicate the specific products, features, or functions required to meet this specification. Alternate or as-equal products submitted under this contract must provide a detailed line-by-line comparison of how the submitted product meets, exceeds or does not comply with this specification.
8. Bill of Materials.
9. Table of contents with page numbering.

H. CONTRACTOR REQUIREMENTS

1. The Security SubContractor shall have a supporting office within 100 miles of the project location
2. Certifications: Two (2) technicians from the supporting office shall hold current certifications with S2 Security
3. On-site maintenance and repair service shall be available locally and within four (4) hours of notification of condition
4. On-site Contractor personnel shall hold all required local, state, and federal licenses
 - a. On-site Contractor personnel shall hold current certifications with S2 Security
5. The Contractor shall provide three (3) references for completed projects of similar scope

I. CLOSEOUT SUBMITTALS

1. Operation and Maintenance Data: For all components and software to include in emergency, operation, and maintenance manuals.
2. Extra Materials:
 - a. Return all left-over (unused) product and materials to the Owner
3. Applicable operating system, database, client, and application software on portable storage

media

4. Full System Backup as of closeout date on portable storage media
5. Submit one (1) printed and one (1) electronic copy of project binder in final form. This copy shall contain as a minimum:
 - a. Table of Contents for each element
 - b. Security SubContractor information - names phone numbers, and email for sales, technical support, and consumables reordering
 - c. Lists of spare parts and replacement components recommended to be stored at the site for ready access
 - d. Datasheets for all equipment
 - e. Operation and maintenance manuals for all equipment
 - f. Operation and maintenance procedures not covered in manufacture's manuals
 - g. Training:
 - 1) Program Syllabus.
 - 2) Manual(s) and Material(s).

J. QUALITY ASSURANCE

1. Installation shall comply with federal, state, and local codes and Authority Having Jurisdiction (AHJ).
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. All software and hardware shall be programmed and installed in accordance with manufacturer's specifications.
4. All equipment shall be new, in current production, and the standard products of a manufacturer of ESS equipment.
5. Manufacturer shall guarantee availability of parts, for a minimum of seven (7) years from date of shipment.
6. On-site maintenance and repair service shall be available locally and within four (4) hours of notification of condition.
7. Security SubContractor shall review drawings and specifications.
8. Software integration between all integrated systems shall be tested and certified for interoperability by the manufacturer of each system.
9. Software integration between the SMS, VMS, and all other integrated system components shall be tested and certified for interoperability by the manufacturers of each system.

K. PERMITS

1. All permits required for the specified performance and completion of the work shall be secured by the Security SubContractor

L. PROJECT CONDITIONS

1. Environmental Conditions: System components shall withstand the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 - a. Interior Environmentally Controlled Space: Rated for continuous operation in ambient temperatures of 32° to 95° F (0° to 35° C) dry bulb and a relative humidity of 20 to 80 percent, noncondensing.

M. WARRANTY

1. Manufacturer's standard form in which manufacturer agrees to service, repair or replace system components as needed for proper system operation as specified herein.
2. Warranty Period: a 2-year warranty on hardware and a 1-year warranty on labor and

software from date of date of Owner Acceptance.

N. OPERATIONAL REQUIREMENTS

1. The SMS shall be implemented through network appliance architecture with a three-tier modular hardware hierarchy and embedded three-tier software architecture.
 - a. The network appliance shall be capable of running on an existing TCP/IP network and shall be accessible, configurable, and manageable from any network-connected PC with a browser.
 - b. Browser access for configuration and administration of the system shall be possible from a PC on the same subnet, through routers and gateways from other subnets, and from the Internet. Control and management of the system shall therefore be geographically independent.
 - c. Security of the data communicated over the network to and from the browser, Network Controller, and field panels shall be protected by TLS protocol encryption. The connection shall use TLSv1.2, GCM mode and a 2048-bit RSA key.
 - d. The top hardware tier shall be the Network Controller. Embedded on the Network Controller shall be an operating system, a web server, security application software, and the database of personnel and system activity. Converged Video Access systems shall also include fully functional network video recorder.
 - e. The middle hardware tier shall be the Network Node. The Network Node shall make and manage access control decisions with data provided by the Network Controller, and it shall manage the communication between the Network Controller and Application Blades connected to the system's inputs, outputs, and readers. This modular design shall make it possible, even during network downtime, for the system to continue to manage access control and store system activity logs. When network connectivity is re-established, the system activity logs shall be automatically re-integrated.
 - f. The bottom hardware tier shall be the Application Blades. Four unique Application Blades shall be available:
 - 1) Access Control Blade: shall support two readers, four supervised inputs, and four relay outputs.
 - 2) Alarm Input Blade: shall support eight supervised inputs.
 - 3) Relay Output Blade: shall support eight relay outputs.
 - 4) Temperature Blade: shall support eight analog temperature sensor inputs.
2. The SMS shall integrate, within a browser interface, access control, alarm monitoring, video monitoring, and temperature monitoring applications. These applications shall be embedded in a three-tier software architecture.
 - a. The database tier shall use PostgreSQL. PostgreSQL is a full featured, high performance database management system that supports ODBC. This shall provide a small footprint, low administration, and a high reliability relational database that is embedded without requiring the use of a separate PC server.
 - b. The web server tier shall be based on an Apache™ embedded web server. This shall provide a graphically rich security management application through a standard web browser.
 - c. The security application software tier contains the business logic. This application shall also be embedded on the Network Controller and requires no additional memory or processing power.
 - d. This three-tiered embedded software design runs within an embedded Linux Ubuntu 16.04 LTS operating system and shall require no client-side software other than a web browser.
3. All equipment and materials used shall be standard components, regularly manufactured,

- and regularly utilized in the manufacturer's system.
4. All S2 systems and components shall have been thoroughly tested and proven in actual use.
 5. The S2 Network Node shall make and manage access control decisions with data provided by the Network Controller, and it shall manage the communication between the Controller and Application Blades connected to the system's inputs, outputs, and readers. The Network Node shall be supplied with 120V AC at a minimum of 2.3 amps. The Network Node can optionally be powered by 12V DC at a minimum of 7Ah. Internal SLA battery backup shall supply sufficient power to provide for an orderly shutdown of the system in case of loss of external power. External battery backup shall be used to provide uninterrupted operation in the event of external power loss. Each Network Node shall support up to seven Application Blades. Communications between the Network Node and Network Controller shall be encrypted and authenticated using TLS digital certificates. Each Network Node shall have the following capabilities:
 - a. Application Blades 7
 - b. Readers 14
 - c. Reader Groups 256
 - d. Access Levels 512
 - e. Portals 14
 - f. Portal Group 64
 - g. Supervised Inputs 56
 - h. Input Groups 64
 - i. Relay Outputs 56
 - j. Output Groups 64
 - k. Temperature Inputs 56
 - l. Time specifications 512
 - m. Time spec groups 512
 - n. Time specs per group 8
 - o. Threat Levels 8
 - p. Threat Level Groups 32
 - q. Holidays 30
 - r. Access levels 512
 - s. Access levels per person 32
 - t. Credentials per person Unlimited
 - u. Card formats 64
 - v. Elevators 14
 - w. Floors 52
 - x. Floor Groups 128
 - y. Time spec groups 512
 - z. Credential Storage Unlimited
 - aa. Activity Log Records 800,000
 - bb. OS Linux
 - cc. Ethernet Ports 1
 - dd. Dimensions (H, W, D) Wall Mount: 17.0in x 15.0in x 6.75in
(43.18cm x 38.1cm x 17.15cm)
 - ee. Dimensions (H, W, D) Rack Mount: 7.0inx19.0in x 15.0in
(17.78cm x 48.26cm x 38.1cm)
 - ff. Weight 18 lbs (8.6 kg)
 - gg. Operation Temperature 32° to 95°F (0° to 35°C)
 - hh. Storage Temperature -4° to 158°F (-20° to 70°C)
 - ii. Relative Humidity 5-90% non-condensing

jj.	MTBF	297,000
kk.	BTU/h	184

6. The Application Blades shall interface with the Network Controller through the Network Node. The Application Blades shall be blade-style circuit cards. There shall be four types of Application Blades:
 - a. S2 Access Control Blade - The access control blade shall receive power via the ribbon cable bus directly from the Network Node blade. The access control blade shall supply up to 500 mA of power to one reader or 250 mA of power to each of two readers.
 - 1) Reader Connectors 2
 - 2) Max Reader Cable Length 500 feet (152m) (18 AWG twisted, shielded)
 - 3) Reader Power 500 mA
 - 4) Input Connectors 4
 - 5) Max Input Cable Length 2000 feet (610m) (22 AWG twisted shielded)
 - 6) Output Connectors 4
7. S2 Input Blade - The input blade shall receive power via the ribbon cable bus directly from the Network Node blade. It shall support a wide variety of input supervision types including normally-open circuit and normally-closed circuits, and zero, one or two resistor configurations.
 - a. Input Connectors 8
 - b. Max Input Cable Length 2000 feet (610m) (22 AWG twisted, shielded)
 - c. Supervision Types 4 (open, closed, normal, alarm)
8. S2 Output Blade - The output blade shall receive power via the ribbon cable bus directly from the Network Node blade. Both normally-open circuit and normally-closed circuit output devices shall be supported. The relay outputs shall support any output devices that operate on the following maximum electrical ratings: 30 Volts DC or AC, 2.5 Amps inductive or 5.0 Amps non-inductive.
 - a. Output Connectors 8
 - b. Contact Type Form C
 - c. Max Electrical Ratings 30 Volts DC, 2.5 Amps Inductive, 5.0 Amps non-inductive.
9. S2 Temperature blade - The temperature blade shall receive power via the ribbon cable bus directly from the Network Node blade.
 - a. Temperature Inputs 8
 - b. Max Temperature Cable Length 1000 feet (305m) (18 AWG twisted, shielded)
 - b. Temperature Range 32° to 158° F (0° to 70° C)
10. All wall-mount enclosures shall have a lock requiring a key, and a cabinet door tamper switch.

11. S2 Software Licensing:
 - a. Software licensing shall be based upon the number of portals, cameras, and select features for one Network Controller. Software license upgrades shall be available if system portal and camera capacity must be increased. The S2 user license shall be valid in perpetuity and shall include one year of software updates from the date of shipment from the factory.
 - b. Licensing shall be controlled by a Product Key and an Activation Key. The Product Key contains the licensed system features and limits. To upgrade your system license to enable more cameras or more portals you will need a new Product Key. The Activation Key contains the software support expiration date. The keys are locked to the system license number. The system license number shall be viewable on-screen on the About page
 - c. All required licensing to support all required access control equipment shall be provided by the integrator. All system upgrade and support plan (SUSPs) shall be current, and if expired, shall be renewed through the next year.
12. Software upgrades shall be possible from a browser on any network-connected PC by uploading a software update to the Network Controller. The Network Controller shall automatically upgrade all connected Network Nodes. No client software installation shall be necessary.

O. EXAMINATION

1. Examine cable pathways including conduit, raceways, cable trays, and other pathway elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
2. Examine rough-in for control cable and conduit systems to controllers, card readers, and other system components to verify conduit and back-box locations prior to installation of system devices
3. Examine available network capacity and support infrastructure. Consult with network administrator for compliance with network standards and capacity
4. Examine install location for compliance with space allocations, installation tolerance, hazards to safe system operation, and other conditions affecting installation
5. Examine roughing-in for LAN, WAN, and IP network before device installation

P. PREPARATION

1. Comply with SIA CP-01 Control Panel Standard.
2. Comply with ANSI/TIA-606-B Labelling Standard.
3. Prepare detailed project planning forms for programming and configuration of the SMS. Fill in all data available from project plans and specifications and publish as project planning documents for review and approval. These may include (but are not limited to):
 - a. Define SMS Partitions.
 - b. For each Location, record setup of Network Controller features and access requirements.
 - c. Propose start and stop times for time zones and holidays, and match up access levels for doors.
 - d. Set up groups, facility codes, software triggers, and list inputs and outputs for each Network Controller.
 - e. Assign action message names and compose messages.
 - f. Set up alarms. Establish trigger actions between events and video surveillance features.
 - g. Prepare and install alarm graphic maps.
 - h. Develop user-defined fields.

- i. Develop screen layout formats.
 - j. Discuss badge layout options; design badges.
 - k. Complete system diagnostics and operation verification.
 - l. Prepare a specific plan for system testing, startup, and demonstration.
 - m. Develop acceptance test concept and, on approval, develop specifics of the test.
 - n. Develop cable and asset-management system details; input data from construction documents. Include system schematics and technical drawings in electronic format.
4. In meetings with Architect and Owner, present Project planning documents and review, adjust, and prepare final programming and configuration documents. Use final documents to program and configure software.

Q. CABLING

1. Comply with NECA 1, "Good Workmanship in Electrical Construction".
2. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
3. Install LAN cables using techniques, practices, and methods that are consistent with Category 6 rating of components and fiber-optic rating of components, and that ensure Category 6 performance of completed and linked signal paths, end to end.
4. Junction boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with tamper resistant fasteners and/or tamper detection switches. In addition, hinged enclosure doors shall be equipped with locking hardware. Boxes above ceiling level in occupied areas of the building shall not be considered accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
5. Install end-of-line resistors at the field device location and not at the controller or panel location.
6. Card Readers and Keypads and Peripheral Devices:
 - a. Install number of conductor pairs recommended by device manufacturer for the functions specified.
 - b. Follow device manufacturer's installation requirements for maximum cable distances and sizes.

R. IDENTIFICATION

1. Label, in plain English, each end of each cable, field panel, patch panel, network switch, or cabinet
 - a. Each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the device as shown
2. At completion, cable and asset management documentation shall reflect as-built conditions

S. SYSTEM SOFTWARE AND HARDWARE

1. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved.
2. Assign the software license(s) to Owner.
3. All default password shall be changed to those selected by the owner
 - a. The Security Subcontractor shall retain no records of passwords for the project

T. FIELD QUALITY CONTROL

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Factory Commissioning: Onsite visit by the Manufacturer's in-house personnel to inspect, test, and assess system programming, functionality, and performance.
3. Tests and Inspections:
 - a. Inspection: Confirm that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
 - b. Pretesting: Configure and pretest system components, wiring, and functions to confirm that they comply with specified requirements.
 - c. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements.
 - d. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least <14 days>. Provide a minimum of 10 days' notice of test schedule.
 - e. Operational Tests: Perform operational system tests to confirm that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
4. The system is considered defective and the project incomplete if it does not pass tests and inspections
5. Prepare test and inspection reports.

U. STARTUP SERVICE

1. Engage a factory-authorized service representative to supervise and assist with startup service.
2. Provide onsite visit by Manufacturer's in-house personnel to train Owner's operations personnel.
3. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
4. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

V. ADJUSTMENTS

1. Occupancy Adjustments: When requested within <30 days> of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project for this purpose. Tasks shall include, but are not limited to, the following:
 - a. Check cable connections
 - b. Confirm system configuration and adjust settings needed
 - c. Recommend changes to the system to improve Owner's use
 - d. Provide a written report of adjustments and recommendations

W. DEMONSTRATION

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the system equipment.
2. Develop and provide separate training modules for the following:
 - a. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
 - b. Operators who prepare and input credentials, monitor the SMS, and to enroll personnel.
 - c. Security personnel.

- d. Hardware maintenance personnel.
- e. Corporate management.

X. MAINTENANCE

- 1. The Security SubContractor shall offer a Software Upgrade and Support Agreement (SUSP)
 - a. The Security subcontractor shall offer the SUSP in 3 year.
 - b. As part of the agreement, normal business hours (9:00 AM – 6:00 PM), manufacture phone support shall be available.
 - c. The option of 24/7 telephone support shall be offered.
 - d. As part of the agreement, access to software patches and software upgrades shall be available.

Y. SECURITY SUBCONTRACTOR RESPONSIBILITY:

- 1. All products shall be new and unused, and be provided from the manufacturer's current and standard production. Where two or more equipment items of the same kind are provided, all shall be identical and provided by the same manufacturer. Drawings and specifications shall indicate major system components, and may not show every component, connector, module, or accessory required to support the operation specified. Security SubContractor will provide all components needed for complete and satisfactory operation.

2.08 VIDEO MANAGEMENT SYSTEM

A. MANUFACTURER

- 1. VMS shall be a unified software with the access control system.
 - a. Lenel/S2
 - b. Genetec
 - c. Avigilon
 - d. Or Equal

B. SUMMARY

- 1. Section includes an S2 Security Corporation NetVR® Video Management System (VMS) consisting of computer hardware, software, and associated licensing and equipment for monitoring, recording, and managing surveillance camera system images and data
- 2. The NetVR VMS shall be used to view live and recorded video from IP cameras connected to a common local and/or wide area network (LAN/WAN)

C. PERFORMANCE REQUIREMENTS

- 1. The NetVR VMS shall be certified by to meet the following standards:
 - a. ISO 9000
 - b. System shall be RoHS (Restriction of Hazardous Substances) compliant and meet proposed amendments to the reduction of toxic substances in manufacturing as stated in the Environmental Design of Electrical Equipment Act (EDEE)
 - c. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency and marked for intended location and application
 - d. Installation shall comply with NECA 1-2010 "Standard Practice of Good Workmanship in Electrical Construction"
 - e. Installation shall comply with NEC/NFPA 70E "Standard for Electrical Safety in

the Workplace”

- f. Electronic data exchange between Video Surveillance System with an Access Control System shall comply with SIA TVAC
- g. Installation shall comply with FCC CFR 47 Part 15 Class A "Telecommunications, Radio Frequency, Digital Device Emission
- h. Installation shall comply with federal, state, and local codes and authorities having jurisdiction (AHJ)

D. ACTION SUBMITTALS

- 1. Product Data: Provide details and technical specifications for each product indicated. Include physical dimensions, features, performance, electrical characteristics, ratings, software versions, and operating system details.
- 2. Shop Drawings: Include system line diagrams, equipment locations, installation details, and system integration plans
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection
 - b. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types, quantities, and sizes
 - c. Plans and Elevations: Dimensioned plans and elevations of equipment racks, including access and workspace requirements
 - d. Data Calculations: Provide VMS bandwidth and storage calculations meeting the minimum project requirements as described herein
 - e. Power and Heat Load Calculations: Provide power and heat load calculations for all hardware, including UPS capacity calculations
 - f. Wiring Diagrams: For power and data wiring
- 3. Equipment and Software List: Include every piece of equipment and software by product/model name and/or number, manufacturer, serial number, revision number, location, and date of original installation. If factory and/or bench testing regimens are required by the project plan, add pretesting record of each piece of equipment and software, listing name of person testing, date of test, and adjustments made.

E. INFORMATIONAL SUBMITTALS

- 1. ISO9000 Listing Certificates
- 2. CE and FCC Compliance Certificates:
- 3. Field quality-control reports
- 4. Warranty: Software support and warranty information for all components, including Service Level Agreement (SLA) details, and duration of agreement from date of system acceptance by Owner
- 5. Current S2 Security Integrator Certification Letter
- 6. Current S2 Security Training Certificates (listing expiration dates) for two technicians from the supporting office

F. CONTRACTOR REQUIREMENTS

- 1. The Contractor shall have a supporting office within 50 miles of the project location
- 2. Certifications: Two (2) technicians from the supporting office shall hold current certifications with S2 Security
- 3. On-site maintenance and repair service shall be available locally and within four hours of notification of condition
- 4. On-site Contractor personnel shall hold all required local, state, and federal licenses

G. CLOSEOUT SUBMITTALS

1. Operation and Maintenance Data: For all components and software to include in emergency, operation, and maintenance manuals.
 - a. Extra Materials:
 - 1) Return all left-over (unused) product and materials to the Owner
 - b. Applicable operating system, database, client, and application software on portable storage media
 - c. Full System Backup as of closeout date on portable storage media
 - d. Submit one (1) printed and one (1) electronic copy of project binder in final form. This copy shall contain as a minimum:
 - 1) Table of Contents for each element
 - 2) Contractor information - names phone numbers, and email for sales, technical support, and consumables reordering
 - 3) Lists of spare parts and replacement components recommended to be stored at the site for ready access
 - 4) Datasheets for all equipment
 - 5) Operation and maintenance manuals for all equipment
 - 6) Operation and maintenance procedures not covered in manufacture's manuals
 - 7) Training:
 - a) Program Syllabus.
 - b) Manual(s) and Material(s).

H. QUALITY ASSURANCE

1. Installation shall comply with federal, state, and local codes and authorities having jurisdiction (AHJ)
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application
3. All software and hardware shall be programmed and installed in accordance with manufacturer's specifications
4. All equipment shall be new, in current production, and the standard products of a manufacturer of ESS equipment
5. Manufacturer shall guarantee availability of parts, for a minimum of seven years from date of shipment
6. On-site maintenance and repair service shall be available locally and within four hours of notification of condition
7. Contractor shall review drawings and specifications
8. Software integration between all integrated systems shall be tested and certified for interoperability by the manufacturer of each system.

I. PERMITS

1. All permits required for the specified performance and completion of the work shall be secured by the Contractor

J. WARRANTY

1. Manufacturer's standard form in which manufacturer agrees to service, repair or replace system components as needed for proper system operation as specified herein.
2. Warranty Period: a Two-year warranty on hardware and a One-year warranty on labor and software. from date of date of Owner Acceptance.

K. MANUFACTURERS

1. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Lenel/S2 Security Corporation
 - b. exacqVision
 - c. Milstone
 - d. Or equal

L. SYSTEM REQUIREMENTS

1. The Video Management System (“VMS”) shall be a software package for comprehensive management of live and recorded video, and associated data.
2. The NetVR software shall have a client/server-based architecture. The system may be configured as a standalone NetVR system (with the client software operating concurrently on the server hardware), the client software running on one or more network-connected TCP/IP workstations, or any combination thereof. Multiple client workstations shall be capable of simultaneously viewing live and/or recorded video from one or more servers. Multiple servers shall also be capable of simultaneously providing live and/or recorded video to one or more client workstations.

M. GENERAL FUNCTIONALITY

1. The NetVR shall be available as an appliance
2. The NetVR shall support monitoring of video from IP cameras and encoding devices and data in real time over local and wide area networks
3. The NetVR shall support single-screen administration across multiple servers and systems
4. The NetVR shall support data integration with access control systems
5. The NetVR shall support e-mail and text (SMS) notifications
6. The NetVR shall offer an open architecture supporting IP cameras and encoders using standard ONVIF protocols
7. The NetVR system shall be configurable for recording based on video motion detection, so that video shall be recorded when the system detects motion within user-defined regions of interest within each camera’s Field-of-View (FoV). The system shall also record pre-event and post-event video based on user-defined operating parameters
8. The NetVR system shall have video management features for monitoring video status of cameras based on user-defined operating parameters. Users shall have the ability to configure the system to annunciate “Loss of Video” status on one or more NetVR clients by way of an on screen visual indicator.
9. The NetVR Client software shall support running multiple instances of the NetVR Client application simultaneously on a single workstation for display on multiple monitors. Subject to limitations of commercially available computer workstation hardware, the NetVR Client software shall support up to twelve (12) simultaneous instances of the NetVR Client running simultaneously on a single workstation. Multiple monitors shall be configurable on a single workstation, with one (1) client application displayed on each monitor. The NetVR Client workstation hardware shall require multi-core processors and display adapters to support this functionality. The NetVR Client workstation shall be equipped with one (1) CPU core for each instance of the NetVR client application to be displayed.
10. The NetVR server software shall operate with the following operating system:
 - a. Linux Ubuntu 14.04 Debian Packages
11. The NetVR system licensing fees shall be determined by the total number of cameras configured on the system and by set of features available to the user. This licensing shall be based on the MAC address of a network card that is present on the system.
12. The NetVR system shall not require the manufacturer to be contacted for a camera on the

system to be replaced. The NetVR system shall allow users to replace cameras without the need for individual camera license keys.

13. The NetVR server software shall run as a service
14. The NetVR shall not require any applications to be running to operate
15. The NetVR shall support the use of panoramic lenses
16. Video Streaming
 - a. Video formats supported: MJPEG, H.264
 - b. Each video stream shall have the ability to be recorded, viewed live, saved to views, exported, and is available for search and playback
 - c. Streams shall be individually configurable for recording schedules and storage rules
 - d. Multistreaming – The VMS shall allow the setting of multiple, independent video streams from the IP camera, when supported by camera model, each configurable for frame rate, resolution, and quality level
 - 1) Each stream shall be able to be recorded, viewed live, saved to views, exported, and available for search and playback
 - 2) All streams can be individually configurable for recording schedules and storage rules
17. Recording
 - a. The NetVR shall support continuous, uninterrupted and unattended recording of all video transmitted to the VMS, including during times of administration and configuration of any feature
 - b. The NetVR shall support recording video based on metadata generated by an edge network device and included in the video stream sent to the VMS server
 - c. The NetVR shall support the configuration of each video input's recording time on an hourly basis, to further allow the user to schedule when to record on motion, when to record on event and when to not record
 - d. The NetVR shall support video recording based on access control events and activity
 - e. The NetVR shall support recording of video and data files, as determined by rules, events, or manual selection
 - f. The NetVR shall support recording video based on the following classifications
 - 1) Continuous Recording (all video all the time)
 - 2) Video associated with motion events as detected by the device
 - 3) Video associated with triggered alarms as configured with an integrated access control solution (as supported by the manufacturer)
 - 4) Activity from an access control system
 - g. The NetVR shall support the configuration of unique weekly recording schedules per camera
 - h. The NetVR shall support a graphical representation of drive status for associated RAID-based storage
 - i. Storage Types
 - 1) The NetVR shall support local HDD disk storage
 - 2) The NetVR shall support JBOD, RAID5 and RAID6 storage configurations through hardware controller and shall not require operating system resources to manage storage
 - j. Storage Retention
 - 1) The NetVR shall support configurable "At Most" rules that will automatically delete video for a camera after a specified amount of time
 - 2) The NetVR shall support configurable "At Least" rules that will delete newer video on other cameras to preserve older video from cameras with an "at least" rule specified

18. File system and operations
 - a. The video file shall contain the data of the video, audio, and associated metadata
 - b. The index file shall contain the index of the metadata from the network device
 - c. When the NetVR searches for video, it shall retrieve and display the information in the index files
 - d. When a client requests to display the video, the NetVR shall transmit the video file data from the server to the client
19. Video Archiving
 - a. The NetVR shall support the archiving of video and data files, as determined by rules, events, or manual selection
 - b. Each archive target has its own set of rules for what cameras and video are archived and when
 - c. The NetVR shall support the archiving of video to multiple Network Attached Storage locations based on the camera name, event type, or an archive schedule
 - d. Schedules – The NetVR shall support continuous or scheduled archiving
 - 1) Archive tasks shall continue until completion of the current requirement or terminate at a scheduled time.
 - 2) Weekly schedules shall be supported.
20. Events - The NetVR shall support events to initiate actions:
 - a. Events:
 - 1) Video motion, operating on the encoded video
 - 2) Video loss of analog video signals
 - 3) Device, server, and system health
 - 4) IP camera connection
 - 5) Date and time
 - b. Actions:
 - 1) Record video
 - 2) Send an email
 - 3) Move a PTZ camera to a preset position
 - c. Users shall have the ability to create rules based on a combination of events

N. HARDWARE

1. VMS appliance shall be based on Linux Ubuntu 14.04 LTS OS
2. Ability to add and change hard-disk storage devices for repair or expansion purposes
 - a. Hard disk operation shall be done through the NetVR GUI and shall not require the operator to initiate command line activity or interface with the operating system
3. The S2 NetVR shall support a solid-state drive to store the application and configuration data. This SSD shall not be used to store video data
4. Events in the access control system shall have the capability to initiate video recording. Video motion detection and camera status messages from the NetVR shall have the capability to initiate alarms.
5. S2 VR Series Products include the NetVR700
6. Multiple subordinate NetVR appliances can be connected to an S2 Security Management System:
 - a. NetBox: Up to 4 subordinate NetVRs, supporting up to 64 cameras
 - b. NetBox VR: Up to 4 subordinate NetVRs (1 included plus 3 additional), supporting up to 64 cameras
 - c. NetBox Extreme: Up to 8 subordinate NetVRs, supporting up to 128 cameras
 - d. Enterprise Select: Up to 64 subordinate NetVRs, supporting up to 1024 cameras
 - e. Enterprise Ultra: Unlimited subordinate NetVRs and cameras
7. NetVR700 Hardware Specifications:

- a. Video Management
 - 1) Max IP Camera Streams 128
 - 2) IP Camera Resolution IP camera dependent
 - 3) IP Camera Frame Rate IP camera dependent
 - 4) Compression type MJPEG, H.264
- b. Platform
 - 1) Max Storage (internal) 48TB or 96TB (4TB or 8TB removable drives)
 - 2) Storage Configuration RAID 5/6
 - 3) Processor Intel Xeon E3-1240v5
 - 4) RAM 8.0 GB DDR3
 - 5) OSUbuntu Linux 16.04 LTS
 - 6) OS/Application Storage 150GB SSD
 - 7) NIC (10/100/1000) 4
 - 8) Sustained Hard Drive Throughput 800Mbps
 - 9) Certifications / Compliances FCC, RoHS
 - 10) Warranty 2 Years (hardware)
 - 11) Chassis 2U (with rail kit)
 - 12) Dimensions (H, W, D) 3.5in x 19.0in x 14.58in (88mm x 482mm x 370mm)
 - 13) Weight 52lbs (23.6Kg)
 - 14) Operation Temperature 50° - 95°F (10° - 35°C)
 - 15) Storage Temperature -40° - 158°F (-40° - 70°C)
 - 16) Operating Environment Humidity 85%, non-condensing
 - 17) AC Input 100 - 240 VAC, 50/60 Hz, 6A/3A
 - 18) Redundant Dual Power Supply 800W
 - 19) MTBF 41,200 hours
 - 20) BTU 2,457
- c. Minimum Client Requirements
 - 1) Operating System Microsoft Windows 7
Microsoft Windows 10
Mac Yosemite (10)
Mac El Capitan (11)
 - 2) Browser Internet Explorer Version 11
Chrome 58
Firefox 53
Safari 8, 9
 - 3) Processor Intel Core i5
 - 4) RAM 8GB
 - 5) Hard Drive 100GB
- d. Platform
 - 1) Max Storage (internal) 96TB or 192TB (4TB or 8TB removable drives)
 - 2) Storage Configuration RAID 5/6
 - 3) Processor Intel Xeon E3-1240v5
 - 4) RAM 8.0 GB DDR3
 - 5) OSUbuntu Linux 16.04 LTS
 - 6) OS/Application Storage 150GB SSD
 - 7) NIC (10/100/1000) 4
 - 8) Sustained Hard Drive Throughput 800Mbps
 - 9) Certifications / Compliances FCC, RoHS
 - 10) Warranty 2 Years (hardware)
 - 11) Chassis 2U (with rail kit)

- 12) Dimensions (H, W, D) 3.5in x 19.0in x 14.58in (88mm x 482mm x 370mm)
- 13) Weight 98lbs (45.4Kg)
- 14) Operation Temperature 50° - 95°F (10° - 35°C)
- 15) Storage Temperature -40° - 158°F (-40° - 70°C)
- 16) Operating Environment Humidity 85%, non-condensing
- 17) AC Input 100 - 240 VAC, 50/60 Hz, 6A/3A
- 18) Redundant Dual Power Supply 1200W
- 19) MTBF 39,100 hours
- 20) BTU 3,685
- e. Minimum Client Requirements
 - 1) Operating System Microsoft Windows 7
Microsoft Windows 10
Mac Yosemite (10)
Mac El Capitan (11)
 - 2) Browser Internet Explorer Version 11
Chrome 58
Firefox 53
Safari 8, 9
 - 3) Processor Intel Core i5
 - 4) RAM 8GB
 - 5) Hard Drive 100GB

O. CLIENT SOFTWARE

1. There shall be no licensing fees associated with the number of concurrent NetVR clients.
2. The NetVR client software shall provide users the capability for viewing live video and audio, recorded video and audio, and the ability to configure the complete system using a single software application.
3. The NetVR client software shall have the same functionality when operating as a network connected client workstation, as it does when operating as a stand-alone system (on the same computer as the server software).
4. The NetVR client software functionality shall be configurable based on user permissions and product feature licenses.
5. The NetVR client software shall be downloadable at no charge from the Manufacturer's web site
6. The NetVR client software shall operate on any of the following operating systems:
 - a. Microsoft Windows 7 (all versions)
 - b. Microsoft Windows 10 (all versions)

7. The NetVR client software shall support simultaneous access to video from multiple servers
 8. Monitoring
 - a. The NetVR client software shall de-warp the image for both live and recorded video
 - b. The NetVR client software shall display access control related data (from supported devices)
 - c. Instant replay shall be available for any video on the operator screen with a single click
 - d. The NetVR client software shall support displaying date, time, weather, road traffic, social media feed and other multimedia content
 - e. The NetVR client software shall support virtual matrix functionality
 9. PTZ
 - a. The NetVR software shall support the following methods of controlling PTZ cameras:
 - 1) PTZ graphics control windows
 - 2) Live graphic overlay PTZ control icons
 - 3) Keyboard control (up, down, left, right arrows; page up, page down for zoom)
 - 4) PTZ preset triggers
 - 5) Digital PTZ functions
 - 6) USB joystick inputs
 - 7) Proportional PTZ control
 10. Forensics
 - a. Ability to switch to forensic activity review based on the video selected
 - b. Ability to call other cameras and other saved views to populate the forensic investigation
 - c. The NetVR client software shall support Search and Playback
 - d. Export
 - 1) The NetVR client software shall support exporting video without overwriting previous exports.
 - 2) The NetVR client software shall support exporting a video segment from specific cameras onto a shared folder, application media folder or directly into a case for investigation purposes.
- P. MOBILE SECURITY PROFESSIONAL (MSP)
1. A free mobile application shall be available from the Manufacturer.
 2. Mobile Security Professional shall support remote view of live and recorded video through the Video Server
 3. Mobile Security Professional shall support simultaneous interaction with multiple NetVRs
 4. Mobile Security Professional shall support monitoring of events
 5. Mobile Security Professional shall support the viewing of video and access control data
- Q. CONFIGURATION
1. All configuration and setup shall be available through the NetVR client software
 2. The NetVR client software shall support automatic identification and IP address assignment of compatible IP cameras and encoders
 3. User administration
 - a. Permissions
 - 1) Authenticate the user's permission level by
 - a) Active Directory or LDAP
 - b) combination of user name and password

- 2) Allow for a user's permissions to be configured across multiple servers from a single screen
 - b. The NetVR client software shall support custom permissions
 - c. The NetVR client software shall support an audit trail of when users log in that shows what changes they have made, what video they have viewed, and what they have exported
 4. The NetVR client software shall support the configuration of the video devices performed in the client and pushed out to the devices
 5. The NetVR client software shall support storing camera settings on both the camera and the VMS
 6. The NetVR client software shall support configuration of the following camera properties on supported cameras:
 - a. Wide Dynamic range
 - b. Auto-focus
 - c. Flip/mirror/rotate
 7. Users shall have the ability to create logical groups of cameras connected to one or more systems.
 8. The NetVR Client software shall support configuration of rules to set the maximum or minimum number of days on a per video stream basis
 9. The NetVR Client software shall support the selection and configuration of drives used for recording video, including local drives, direct attached storage drives, or iSCSI drives
- R. WEB CLIENT
1. The NetVR software shall allow authorized users to view video through a web client interface. The web client interface shall allow authorized users to view live video; views recorded video, control pan-tilt zoom (PTZ) cameras, and activate event triggers. The web client interface shall allow connections to multiple NetVR servers simultaneously.
 2. When operating the web client interface, the NetVR server shall automatically transcode the requested video into a JPEG file size consistent with the browser screen resolution before making it available to the browser.
 3. The web client interface shall support the following browsers:
 - a. Internet Explorer 11 and later
 - b. Chrome 58 and later
 - c. Firefox 53 and later
 - d. Safari 8, 9 and later
- S. S2 CUMULUS REMOTE MONITOR AND ADMINISTRATOR
1. The system shall support cloud-based monitoring and administration of S2 access control and video systems from a single management dashboard.
 2. S2 Cumulus shall support S2 NetBox, S2 NetVR, S2 Global, and S2 Magic Monitor
 3. S2 Cumulus shall support remote monitoring of the following:
 - a. The last communication with Cumulus
 - b. Status of the CPU
 - c. Memory and network bandwidth usage
 4. S2 Cumulus shall support the managing of system licenses, including:
 - a. OS version
 - b. S2 software version
 - c. SUSP expiration date
 - d. Detailed license information
- T. S2 Cumulus shall support remote updating of the system's software

1. S2 Cumulus shall be accessible through the S2 Integrator Portal
2. S2 Cumulus shall not require ports to be opened for communications from the S2 NetBox, S2 NetVR, S2 Global, or S2 Magic Monitor
3. S2 Cumulus shall support the sending of email or text alerts to system users when a system has an error
 - a. Alerts shall be able to be grouped together

U. EXAMINATION

1. Examine cable pathways including conduit, raceways, cable trays, and other pathway elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
2. Examine rough-in for control cable and conduit systems to controllers, card readers, and other system components to verify conduit and back-box locations prior to installation of system devices
3. Examine available network capacity and support infrastructure. Consult with network administrator for compliance with network standards and capacity
4. Examine install location for compliance with space allocations, installation tolerance, hazards to safe system operation, and other conditions affecting installation
5. Examine roughing-in for LAN, WAN, and IP network before device installation

V. PREPARATION

1. Prior to beginning system programming, prepare detailed project planning forms for programming and configuration of the system. Fill in all data available from project plans and specifications and publish as project planning documents for review and approval. These may include (but are not limited to):
 - a. Define user (operator) types
 - b. Define camera naming schema
 - c. Determine storage requirements
 - d. Determine FPS requirements
 - e. Determine motion recording
 - f. Define event programming
 - g. Develop matrix layouts
 - h. Prepare a project specific plan for system testing, startup, and demonstration
 - i. Develop cable and asset-management system labeling plan
2. In meetings with Architect and Owner, present Project planning documents and review, adjust, and prepare final programming and configuration documents. Use final documents to program and configure software.

W. CABLING

1. Comply with NECA 1, "Good Workmanship in Electrical Construction".
2. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
3. Install LAN cables using techniques, practices, and methods that are consistent with Category 6 rating of components and fiber-optic rating of components, and that ensure Category 6 performance of completed and linked signal paths, end to end.
4. Junction boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with tamper resistant fasteners and/or tamper detection switches. In addition, hinged enclosure doors shall be equipped with locking hardware. Boxes above ceiling level in occupied areas of the building shall not be considered accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be

covered with a suitable cover plate and secured with tamperproof screws.

X. IDENTIFICATION

1. Label, in plain English, each end of each cable, field panel, patch panel, network switch, or cabinet
 - a. Each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the device as shown
2. At completion, cable and asset management documentation shall reflect as-built conditions

Y. SYSTEM SOFTWARE AND HARDWARE

1. Develop, install, and test software and hardware, and perform tests for the complete and proper operation of systems involved
2. Assign the software license(s) to Owner
3. All default password shall be changed to those selected by the owner
 - a. The contractor shall retain no records of passwords for the project

Z. FIELD QUALITY CONTROL

- a. Factory Commissioning: Onsite visit by the Manufacturer's in-house personnel to inspect, test, and assess system programming, functionality, and performance.
- b. Tests and Inspections:
- c. Inspection: Confirm that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
- d. Pretesting: Configure and pretest NetVR components, wiring, and functions to confirm that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
 - 1) Prepare equipment list
 - 2) Confirm operation of all camera streams and check data storage configuration.
 - 3) Confirm operation of all third-party integrated components and systems
 - 4) Set and name all camera streams and preset positions; consult Owner's personnel.
 - 5) Confirm operation of monitoring equipment.
2. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
3. Operational Tests: Perform operational system tests to confirm that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
4. The system is considered defective and the project incomplete if it does not pass tests and inspections
5. Prepare test and inspection reports

AA. ADJUSTMENTS

1. Occupancy Adjustments: When requested within 30 days of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project for this purpose. Tasks shall include, but are not limited to, the following:
 - a. Check cable connections

- b. Check proper operation of cameras streams and storage configuration
- c. Confirm system configuration and adjust settings needed
- d. Recommend changes to the system to improve Owner's use
- e. Provide a written report of adjustments and recommendations

BB. DEMONSTRATION

- 1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment
- 2. Develop and provide separate training modules for the following:
 - a. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
 - b. Security monitoring personnel
 - c. Hardware maintenance personnel
 - d. Corporate management

CC. MAINTENANCE

- 1. The Contractor shall offer a Software Upgrade and Support Agreement (SUSP)
 - a. The Contractor shall offer the SUSP in 3 year increments.
 - b. As part of the agreement, manufacture phone support shall be available from (9:00 AM – 7:00 PM) on a normal business day
 - c. The option of 24/7 telephone support shall be offered.
 - d. As part of the agreement, access to software patches and software upgrades shall be available.

2.09 HARDWARE AND PERIPHERALS

A. CLIENT WORKSTATION

- 1. Security Control Workstation (Client)
 - a. Provide security workstations with the following specifications. Provide a UPS with battery backup for 10 minutes for each workstation. The security control workstation shall be used for the USP. Each workstation CPU shall be rack mounted in the MDF. Provide KVM extenders as shown below for all monitors, keyboards and mice.
 - 1) Four Core Xeon 3.6 GHz or higher, 20 MB Cache
 - 2) Microsoft Windows 7
 - 3) 16GB RAM
 - 4) 200 GB of storage or more.
 - 5) NVIDIA Quadro 4000, dual mon or better. Provide with quad monitor card.
 - 6) 1280x1024 or higher screen resolution
 - 7) 10/100/1000 Ethernet Network Interface Card
 - 8) 16x DVD/RW Drive
 - b. Provide a 26 in. LED monitor with each workstation.
 - c. Provide Dell Precision T3600 series or approved equal.
 - d. Provide a minimum of one (1). Provide as shown on the drawings.
- 2. Core and Edge Network Switch
 - a. Provide Power over Ethernet (PoE) network switch(s) for all cameras, access control panels, encoders/decoders, security workstations, video servers, and access control servers.
 - b. Each switch shall have 20 percent spare capacity per closet/IDF/MDF.

- c. Each closet shall support 10/100mbps per port with a minimum of 1000GB on the back bone/core switch. The fiber infrastructure shall be only utilized for connectivity from each IDF to the MDF/core switch. The use of any portion of the copper back bone shall not be allowed.
 - d. Provide a layer 3 core switch which shall support each IDF/remote security closet with 1000gbs bandwidth over the fiber infrastructure. In addition to the support of each closet, provide a dedicated 1000gbs for each server (access control and video). Provide 20 percent 1000gbs copper ports and 20 percent spare 1000gbs fiber ports at the core switch/head end.
 - e. PoE network switches must support by same manufacturer a redundant power supply option. Though not a requirement at this time, proposed network switches must have this option without replacement of network switches.
 - f. Provide Uninterruptible Power Supply (UPS) for each closet/IDF/MDF to support the network PoE Switches. For closet locations requiring 24 ethernet ports or less, install a 500VA UPS similar to Minuteman model E500. For closet locations requiring more than 24 Ethernet ports, provide and install a 1000VA UPS similar to the Minuteman E1100.
 - g. Each network switch shall be located in each IDF/MDF.
 - h. Provide Extreme network switches for the core switch in MDF. Provide fiber GBIC cards and module as required to support each IDF and/or security closet as shown on the drawings and riser diagram.
 - i. Provide Extreme network switches for each edge switch. Each switch shall include a minimum of one (1) fiber GBIC card and module.
 - j. Provide an interface to the owner's LAN as required.
3. Interior/Exterior Fixed Cameras
- 1) Provide cameras with the following specifications for all outdoor fixed cameras as shown on the drawings. Provide with sunshade for wall mounted units.
 - 2) Basis of design AXIS P3265-LVE model Fixed dome 1080p network camera
 - a) The fixed dome network camera shall meet or exceed the following design specifications:
 - b) The camera shall operate on an open source; Linux-based platform, and including a built-in web server.
 - c) The camera shall be equipped with an IR-sensitive progressive scan megapixel sensor.
 - d) The camera shall provide a removable IR-cut filter, providing day/night functionality.
 - e) The camera shall be equipped with a varifocal lens with P-iris.
 - f) The camera shall provide local video storage utilizing a microSD/microSDHC/microSDXC memory card expansion.
 - g) The camera shall be manufactured with an IP66- and NEMA 4X-rated, IK10 impact-resistant casing.
 - h) The camera shall provide a manual 3-axis (pan/tilt/rotation) positioning to allow adjustment for optimum camera rotation and placement.
 - i) The camera shall provide options for clear and smoked lower dome.
 - 3) The fixed dome network camera shall meet or exceed the following performance specifications:
 - a) Illumination
 - b) The camera shall meet or exceed the following illumination

- specifications:
 - c) HDTV 1080p 25/30 fps with WDR - forensic capture
 - d) 0.16 lux at 50 IRE, F1.4 (color)
 - e) 0.03 lux at 50 IRE, F1.4, 0 lux with IR illumination on (B/W)
 - f) HDTV 1080p 50/60 fps without WDR - forensic capture
 - g) 0.32 lux at 50 IRE, F1.4 (color)
 - h) 0.06 lux at 50 IRE, F1.4, 0 lux with IR illumination on (B/W)
 - 4) Resolution
 - a) The camera shall be designed to provide at least two video streams in HDTV 720p (1280x720) at up to 60 frames per second (60Hz mode) or 50 frames per second (50Hz mode) using H.264 or Motion JPEG (WDR inactive).
 - b) The camera shall be designed to provide at least two video streams in HDTV 720p (1280x720) at up to 30 frames per second (60Hz mode) or 25 frames per second (50Hz mode) using H.264 or Motion JPEG (WDR active).
 - c) The camera shall be designed to provide 2 individually cropped out view areas.
 - d) The camera shall support video resolutions including:
 - e) 1920x1080 (HDTV 1080p)
 - f) 1280x960
 - g) 1280x720 (HDTV 720p)
 - h) 1024x768
 - i) 1024x640
 - 5) The camera shall provide both landscape format (4:3 and 16:9 aspect ratio) as well as corridor format (3:4 and 9:16 aspect ratio).
 - 6) Encoding
 - a) The camera shall support the following video encoding algorithms:
 - b) Motion JPEG encoding in a selectable range from 1 up to 25/30 frames per second.
 - c) Motion JPEG encoding in a selectable range from 1 up to 50/60 frames per second.
 - d) Baseline Profile H.264 encoding with motion estimation in up to 25/30 frames per second.
 - e) Baseline Profile H.264 encoding with motion estimation in up to 50/60 frames per second.
 - f) Main Profile H.264 encoding with motion estimation and context-adaptive binary arithmetic coding (CABAC) in up to 25/30 frames per second.
 - g) Main Profile H.264 encoding with motion estimation and context-adaptive binary arithmetic coding (CABAC) in up to 50/60 frames per second.
 - h) Support High Profile H.264 encoding with motion estimation up to 25/30 frames per second.
 - i) Support High Profile H.264 encoding with motion estimation up to 50/60 frames per second.
 - j) Support H.264 with automatic scene adaptive bitrate control.
 - 7) The camera shall provide independently configured simultaneous H.264 and Motion JPEG streams.
 - 8) The camera shall in H.264 support Variable Bit Rate (VBR) for video quality adapted to scene content. To protect the network from unexpected

- bit rate speaks the camera shall support Constant Bit Rate (CBR) or Maximum Bit Rate (MBR).
- 9) The camera shall provide configurable compression levels.
 - 10) Support standard baseline profile H.264 with motion estimation.
 - 11) Support motion estimation in H.264/MPEG-4 Part 10/AVC.
 - 12) The camera shall for its H.264 implementation support scene adaptive bitrate control with automatic dynamic ROI to reduce bitrate in unprioritized regions in order to lowering bandwidth and storage requirements.
 - 13) Transmission
 - a) The camera shall allow for video to be transported over:
 - b) HTTP (Unicast)
 - c) HTTPS (Unicast)
 - d) RTP (Unicast & Multicast)
 - e) RTP over RTSP (Unicast)
 - f) RTP over RTSP over HTTP (Unicast)
 - 14) The camera shall support Quality of Service (QoS) to be able to prioritize traffic.
 - 15) Image
 - a) The camera shall incorporate Automatic and Manual White Balance.
 - b) The camera shall incorporate an electronic shutter operating in the range of
1/66500 s to 1 s.
 - 16) The camera shall incorporate capture mode with the following settings:
 - a) 25/30 fps (WDR-Forensic Capture) (50/60 Hz)
 - b) 50/60 fps (no WDR-Forensic Capture) (50/60 Hz)
 - 17) The camera shall incorporate Wide Dynamic Range - Forensic Capture functionality providing up to 120dB dynamic range.
 - 18) The camera shall support manually defined values for:
 - a) Color level
 - b) Brightness
 - c) Sharpness
 - d) Contrast
 - 19) The camera shall incorporate a function for optimization of low light behavior.
 - 20) The camera shall allow for rotation of the image in steps of 90°.
 - 21) IR Illumination
 - a) The camera shall be equipped with built-in IR LEDs with adjustable illumination intensity.
 - b) The IR LEDs shall have a range of up to 30 m (100 ft).
 - c) The IR LEDs shall emit light with a wavelength of 850 nm.
 - 22) User Interface
 - a) Web server
 - b) The camera shall contain a built-in web server making video and configuration available to multiple clients in a standard operating system and browser environment using HTTP, without the need for additional software.
 - c) Optional components downloaded from the camera for specific tasks, e.g. Active X, shall be signed by an organization providing digital trust services, such as Verisign, Inc.
 - 23) Language Specification
 - a) The camera shall provide a function for altering the language of the

- user interface, and shall include support for at least 10 different languages.
- 24) IP addresses
 - a) The camera shall support both fixed IP addresses and dynamically assigned IP addresses provided by a Dynamic Host Control Protocol (DHCP) server.
 - b) The camera shall allow for automatic detection of the camera based on UPnP and Bonjour when using a PC with an operating system supporting this feature.
 - c) The camera shall provide support for both IPv4 and IPv6.
 - 25) PTZ functionality
 - a) The camera shall:
 - b) Provide Digital PTZ functionality.
 - 26) Event functionality
 - a) The camera shall be equipped with an integrated event functionality, which can be triggered by:
 - b) Video Motion Detection
 - c) Live Stream Accessed
 - d) Day/Night Mode
 - e) Camera tampering
 - f) Manual Trigger/Virtual Inputs
 - g) PTZ functionality
 - h) Embedded third party applications
 - i) Edge storage disruption detection
 - 27) Response to triggers shall include:
 - a) Send notification, using HTTP, HTTPS, TCP, SNMP trap or email
 - b) Send images, using FTP, HTTP, HTTPS, network share or email
 - c) Send video clip, using FTP, HTTP, HTTPS, network share or email
 - d) Send SNMP trap message
 - e) Activate/Deactivate IR Illumination
 - f) Recording to local storage and/or network attached storage
 - g) PTZ control functionality
 - h) WDR mode
 - i) The camera shall provide memory for pre & post alarm recordings.
 - 28) Edge storage
 - a) The camera shall support continuous and event controlled recording to:
 - b) Local memory added to the cameras microSD-card slot
 - c) Network attached storage, located on the local network
 - d) The camera shall be able to detect and notify Edge storage disruptions.
 - 29) Protocol
 - a) The camera shall incorporate support for at least IPv4/v6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, TCP, ICMP, SNMPv1/v2c/v3 (MIB-II), RTSP, RTP, UDP, IGMP, RTCP, SMTP, FTP, DHCP, UPnP, ARP, DNS, DynDNS, SOCKS, SSH, NTP, CIFS/SMB, Bonjour.
 - b) The SMTP implementation shall include support for SMTP authentication.
 - 30) Text overlay
 - a) The camera shall:

- b) Provide embedded on-screen text with support for date & time, and a customer-specific text, camera name, of at least 45 ASCII characters.
 - c) Provide the ability to apply privacy masks to the image.
 - d) Allow for the overlay of a graphical image, such as a logotype, into the image.
- 31) Security
- a) The camera shall support the use of HTTPS and SSL/TLS, providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.
 - b) The camera shall provide centralized certificate management, with both pre-installed CA certificates and the ability to upload additional CA certificates. The certificates shall be signed by an organization providing digital trust services.
 - c) The camera shall support IEEE 802.1X authentication.
 - d) The camera shall provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.
 - e) The camera shall restrict access to the built-in web server by usernames and passwords at three different levels.
- 32) API support
- a) The camera shall be fully supported by an open and published API (Application Programmers Interface), which shall provide necessary information for integration of functionality into third party applications.
 - b) The camera shall conform to ONVIF profile G as defined by the ONVIF Organization.
 - c) The camera shall conform to ONVIF profile S as defined by the ONVIF Organization.
 - d) The camera shall conform to ONVIF profile T as defined by the ONVIF Organization.
 - e) For ONVIF profile specifications, see www.onvif.org/
- 33) Embedded applications
- a) The camera shall provide a platform allowing the upload of third party applications into the camera.
 - b) Installation and maintenance

- c) The camera shall be supplied with Windows-based management software which allows the assignment of IP addresses, upgrade of firmware and backup of the cameras' configuration.
 - d) The camera shall support the use of SNMP-based management tools according to SNMP v1, 2c & 3 / MIB-II.
 - e) The camera shall allow updates of the software (firmware) over the network, using FTP or HTTP.
 - f) The camera shall provide the ability to apply a rectangle of customer-defined number of pixels to the image, which can be used as a pixel counter identifying the size of objects in number of pixels.
 - g) The camera shall accept external time synchronization from an NTP (Network Time Protocol) server.
 - h) The camera shall store all customer-specific settings in a non-volatile memory that shall not be lost during power cuts or soft reset.
 - i) The camera shall provide Remote zoom and Remote focus functionality.
- 34) Access log
- a) The camera shall provide a log file, containing information about the 250 latest connections and access attempts since the unit's latest restart. The file shall include information about the connecting IP addresses and the time of connecting.
 - b) Provide a connection list of all currently connected viewers. The file shall include information about connecting IP address, time of connecting and the type of stream accessed.
- 35) Camera diagnostics
- a) The camera shall be equipped with LEDs, capable of providing visible status information. LEDs shall indicate the camera's operational status and provide information about power, communication with receiver, the network status and the camera status.
 - b) The camera shall be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.
 - c) The camera shall send a notification when the unit has re-booted and all services are initialized.
- 36) Hardware interfaces
- a) Network interface
 - b) The camera shall be equipped with one 10BASE-T/100BASE-TX Fast Ethernet-port using a shielded RJ45 connector, and shall support auto negotiation of network speed (100 MBit/s and 10 MBit/s) and transfer mode (full and half duplex).
- 37) Enclosure
- a) The camera shall:
 - b) Be manufactured with an IP66- and NEMA 4X-rated, IK10 impact-resistant casing.
 - c) Be fitted with a dehumidifying membrane.
 - d) Providing encapsulated electronics and captive screws.
- 38) Power
- a) Power over Ethernet IEEE 802.3af/802.3at Type 1 Class 3
 - b) Max: 10.8 W
 - c) Typical 7.3 W

- 39) Environmental
 - a) Operate in a temperature range of -30 °C to +50 °C (-22 °F to 122 °F).
 - b) Operate in a humidity range of 10–100% RH (condensing).
4. Interior/Exterior 360 multi-sensor camera:
 - a. Provide cameras with the following specifications for all indoor/outdoor 360 cameras as shown on the drawings. The basis of design is Axis P3727-PLE.
 - b. Panoramic network camera
 - c. The panoramic network camera shall meet or exceed the following design specifications:
 - 1) The camera shall operate on an open source; Linux-based platform, and including a built-in web server.
 - 2) The camera shall be equipped with four progressive scan megapixel sensors.
 - 3) The camera shall provide flexible positioning of four varifocal camera heads.
 - 4) The camera shall provide the following field of view:
 - a) 4x 1080p
 - b) Horizontal: 108° - 54°
 - c) Vertical: 57° - 30°
 - d) 4x 720p
 - e) Horizontal: 67° - 36°
 - f) Vertical: 37° - 20°
 - d. The camera shall provide adjustable focus and zoom functionality.
 - e. The camera shall provide local video storage utilizing a microSD/microSDHC/microSDXC memory card expansion.
 - f. The camera shall be manufactured with an IP66-, NEMA 4X- and IK09-rated Die-casted aluminum casing.
 - g. The camera shall provide:
 - 1) Pan $\pm 90^\circ$
 - 2) Tilt 28° - 92°
 - 3) Rotate $\pm 90^\circ$
5. The panoramic network camera shall meet or exceed the following performance specifications:
 - a. Illumination
 - 1) The camera shall meet or exceed the following illumination specifications:
 - a) 0.3 lux in color
 - b. Resolution
 - 1) The camera shall be designed to provide 4x video streams in HDTV 1080p (1920x1080) at up to 15 frames per second (60Hz mode) or 12.5 frames per second (50Hz mode) using H.264 or Motion JPEG.
 - 2) The camera shall be designed to provide 4x video streams in HDTV 720p (1280x720) at up to 30 frames per second (60Hz mode) or 25 frames per second (50Hz mode) using H.264 or Motion JPEG.
 - 3) The camera shall be designed to provide quad view in resolution up to 1920x1440
 - 4) The camera shall support video resolutions including:
 - a) 1920x1440 (Quad view)
 - b) 1920x1080 (HDTV 1080p)
 - c) 1280x720 (HDTV 720p)
 - 5) The camera shall provide both landscape format (4:3 and 16:9 aspect ratio)

as well as corridor format (3:4 and 9:16 aspect ratio).

c. Encoding

- 1) The camera shall support the following video encoding algorithms:
 - a) Motion JPEG encoding in a selectable range from 1 up to 25/30 frames per second in all resolutions.
 - b) Baseline Profile H.264 encoding with motion estimation in up to 25/30 frames per second.
 - c) Main Profile H.264 encoding with motion estimation and context-adaptive binary arithmetic coding (CABAC) in up to 25/30 frames per second.
 - d) Support High Profile H.264 encoding with motion estimation up to 25/30 frames per second.
 - e) Support H.264 with automatic scene adaptive bitrate control in up to 25/30 frames per second.
- 2) The camera shall provide independently configured simultaneous H.264 and Motion JPEG streams.
- 3) The camera shall in H.264 support Variable Bit Rate (VBR) for video quality adapted to scene content. To protect the network from unexpected bit rate speaks the camera shall support Constant Bit Rate (CBR) or Maximum Bit Rate (MBR).
- 4) The camera shall provide configurable compression levels.
- 5) Support standard baseline profile H.264 with motion estimation.
- 6) Support motion estimation in H.264/MPEG-4 Part 10/AVC.
- 7) The camera shall for its H.264 implementation support scene adaptive bitrate control with automatic dynamic ROI to reduce bitrate in unprioritized regions in order to lowering bandwidth and storage requirements.

d. Transmission

- 1) The camera shall allow for video to be transported over:
 - a) HTTP (Unicast)
 - b) HTTPS (Unicast)
 - c) RTP (Unicast & Multicast)
 - d) RTP over RTSP (Unicast)
 - e) RTP over RTSP over HTTP (Unicast)
- 2) The camera shall support Quality of Service (QoS) to be able to prioritize traffic.

e. Image

- 1) The camera shall incorporate Automatic and Manual White Balance.
- 2) The camera shall incorporate an electronic shutter operating in the range of:
 - a) 720p: 1/28000 s to 2 s
 - b) 1080p: 1/22500 s to 2 s
- 3) The camera shall incorporate capture mode with the following settings:
 - a) HDTV 1080p 12.5/15 fps
 - b) HDTV 720p 25/30 fps
- 4) The camera shall support manually defined values for:
 - a) Color level
 - b) Brightness
 - c) Sharpness
 - d) Contrast
- 5) The camera shall incorporate a function for optimization of low light behavior.
- 6) The camera shall allow for rotation of the image in steps of 90°.

- 7) The camera shall incorporate local contrast functionality.
- f. User Interface
 - 1) Web server
 - a) The camera shall contain a built-in web server making video and configuration available to multiple clients in a standard operating system and browser environment using HTTP, without the need for additional software.
 - b) Optional components downloaded from the camera for specific tasks, e.g. Active X, shall be signed by an organization providing digital trust services, such as Verisign, Inc.
 - 2) Language Specification
 - a) The camera shall provide a function for altering the language of the user interface, and shall include support for at least 10 different languages.
 - 3) IP addresses
 - a) The camera shall support both fixed IP addresses and dynamically assigned IP addresses provided by a Dynamic Host Control Protocol (DHCP) server.
 - b) The camera shall allow for automatic detection of the camera based on UPnP and Bonjour when using a PC with an operating system supporting this feature.
 - c) The camera shall provide support for both IPv4 and IPv6.
- g. Event functionality
 - 1) The camera shall be equipped with an integrated event functionality, which can be triggered by:
 - a) Video Motion Detection
 - b) Live Stream Accessed
 - c) Camera tampering
 - d) Manual Trigger/Virtual Inputs
 - e) Embedded third party applications
 - f) Edge storage disruption detection
 - 2) Response to triggers shall include:
 - a) Send notification, using HTTP, HTTPS, TCP, SNMP trap or email
 - b) Send images, using FTP, HTTP, HTTPS, network share or email
 - c) Send video clip, using FTP, HTTP, HTTPS, network share or email
 - d) Recording to local storage and/or network attached storage
 - e) Overlay Text
 - 3) The camera shall provide memory for pre & post alarm recordings.
- h. Edge storage
 - 1) The camera shall support continuous and event controlled recording to:
 - a) Local memory added to the cameras SD-card slot
 - b) Network attached storage, located on the local network
 - c) The camera shall be able to detect and notify Edge storage disruptions.
- i. Protocol
 - 1) The camera shall incorporate support for at least IPv4/v6, HTTP, HTTPS, SSL/TLS, QoS Layer 3 DiffServ, TCP, ICMP, SNMPv1/v2c/v3 (MIB-II), RTSP, RTP, UDP, IGMP, RTCP, SMTP, FTP, DHCP, UPnP, ARP, DNS, DynDNS, SOCKS, SSH, NTP, CIFS/SMB, Bonjour.
 - 2) The SMTP implementation shall include support for SMTP authentication.
- j. Text overlay

- 1) The camera shall:
 - a) Provide embedded on-screen text with support for date & time, and a customer-specific text, camera name, of at least 45 ASCII characters.
 - b) Provide the ability to apply privacy masks to the image.
 - c) Allow for the overlay of a graphical image, such as a logotype, into the image.
- k. Security
 - 1) The camera shall support the use of HTTPS and SSL/TLS, providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.
 - 2) The camera shall provide centralized certificate management, with both pre-installed CA certificates and the ability to upload additional CA certificates. The certificates shall be signed by an organization providing digital trust services.
 - 3) The camera shall support IEEE 802.1X authentication.
 - 4) The camera shall provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.
 - 5) The camera shall restrict access to the built-in web server by usernames and passwords at three different levels.
- l. API support
 - 1) The camera shall be fully supported by an open and published API (Application Programmers Interface), which shall provide necessary information for integration of functionality into third party applications.
 - 2) The camera shall support relevant ONVIF profiles as defined by the ONVIF Organization.
- m. Embedded applications
 - 1) The camera shall provide a platform allowing the upload of third party applications into the camera.
- n. Installation and maintenance
 - 1) The camera shall be supplied with Windows-based management software which allows the assignment of IP addresses, upgrade of firmware and backup of the cameras' configuration.
 - 2) The camera shall support the use of SNMP-based management tools according to SNMP v1, 2c & 3 / MIB-II.
 - 3) The camera shall allow updates of the software (firmware) over the network, using FTP or HTTP.
 - 4) The camera shall provide the ability to apply a rectangle of customer-defined number of pixels to the image, which can be used as a pixel counter identifying the size of objects in number of pixels.
 - 5) The camera shall accept external time synchronization from an NTP (Network Time Protocol) server.
 - 6) The camera shall store all customer-specific settings in a non-volatile memory that shall not be lost during power cuts or soft reset.
- o. Access log
 - 1) The camera shall provide a log file, containing information about the 250 latest connections and access attempts since the unit's latest restart. The file shall include information about the connecting IP addresses and the time of connecting.
 - 2) Provide a connection list of all currently connected viewers. The file shall include information about connecting IP address, time of connecting and the type of stream accessed.

- p. Camera diagnostics
 - 1) The camera shall be equipped with LEDs, capable of providing visible status information. LEDs shall indicate the camera's operational status and provide information about power, communication with receiver, the network status and the camera status.
 - 2) The camera shall be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.
 - 3) The camera shall send a notification when the unit has re-booted and all services are initialized.
- q. Hardware interfaces
 - 1) Network interface
 - a) The camera shall be equipped with one 10BASE-T/100BASE-TX PoE Fast Ethernet-port, using a standard male RJ45 connector and shall support auto negotiation of network speed (100 MBit/s and 10 MBit/s) and transfer mode (full and half duplex).
- r. Enclosure
 - 1) The camera shall:
 - a) Be manufactured with an IP66-, NEMA 4X- and IK09-rated Die-casted aluminum casing.
 - b) Be fitted with a polycarbonate dome.
- s. Power
 - 1) Power over Ethernet IEEE 802.3af/802.3at Type 1 Class 2
 - 2) Typical 4.8 W
 - 3) Max 5.5 W
- t. Environmental
 - 1) Operate in a temperature range of -30 °C to +60 °C (-22 °F to 140 °F).
 - 2) Operate in a humidity range of 10–100% RH (condensing).
- 6. Reader and Input/Output (I/O)Control Panels
 - a. General
 - 1) The control panels include but no limited to card reader modules, input modules, output modules, power supply, harnesses, and batteries. Provide quantities as required for a complete working system. Each module card shall be neatly installed in a locked wall cabinet. Enclosures shall be located in each IDF/MDF or as shown on the drawings. Each controller shall be connected to the security network switch. Provide Hoffman enclosures or approved equal.
 - b. Provide Mercury Security Corp. EP1502 with two reader interface intelligent controller.
 - c. Provide Mercury Security Corp. MR52 reader interface.
 - d. Provide Mercury Security Corp. 16 door power supply AC-LSP-16DR-MER.
 - e. Provide HID VertX series or approved equal. Provide with wall mounted cabinet and locking front door equal to Hoffman.
- 7. Combination Card Reader and Keypad
 - a. Provide contactless smart card readers with keypad as shown on the drawings.
 - b. Each reader shall operate on a 13.56 transmit frequency.
 - c. The reader shall have a Weigand output.
 - d. The readers shall have both an audio and visual notification for access granted and access denied.
 - e. The reader shall be suitable for indoor and outdoor applications.
 - f. The reader shall operate up to 500ft on 22AWG cable.

- g. The reader shall be able to communicate with either 2K, 16K or 32K bit iClass cards.
 - h. Provide HID Signo readers.
- 8. Contactless Printable Smart Cards
 - a. The smart card shall be multi-technology triple interface cards and shall be an iClass card manufactured by HID Corporation.
 - b. iCLASS Operating Frequency UHF Operating Frequency 13.56 MHz 860-960 MHz.
 - c. iCLASS Typical Maximum Read Range UHF Typical Maximum Read Range 3-4 in. (depending the reader used) 18-21 ft. (depending the reader used).
 - d. UHF Technology EPC Class1 Gen2 protocol compliant.
 - e. UHF Memory 512 bits of user memory, 128 bits of EPC memory.
 - f. Construction Composite with 60% PET/40% PVC.
 - g. Operating Temperature -40° to 158° F (-40° to 70° C).
 - h. iCLASS Baud Rate 14443 B2 mode - 212 kbps 15693 mode - 26 kbps.
 - i. iCLASS Memory Type EEPROM, Read/write.
 - j. iCLASS Multi-application Memory 32k bit (4K Bytes) card – 16k bits in 2 or 16 application areas plus 16k bits user.
 - k. Card Options Magnetic Stripe, External Card Numbering, Custom Artwork (Text or Graphics).
 - l. Supported Readers Any reader that can read Proximity 125 KHz, iCLASS or iCLASS SE Technology.
 - m. Provide HID iClass Card model 600 or approved equal.
 - n. Provide 50.
 - o. Cards shall be compatible with existing readers used in the district (current cards are HID ISO 36 bit)
 - p. IECS contractor shall program and print the number of badges required by the owner not to exceed 20 in addition program (3) of the badges as Visitor badges coordinate privileges with owner and Label them clearly with the word Visitor on each badge.
- 9. Contactless Key fob
 - a. Provide equivalent contactless key fobs to proximity cards. Quantity (50).
- 10. Door Contacts
 - a. Furnish and install 3/4 in. recessed magnetic door contacts as shown on the drawings.
 - b. Provide Sentrol/GE 1078C or equal unless noted below.
 - c. Provide DPDT contacts for all exterior doors which have a card reader. The second pole will be wired and connected to the intrusion alarm system. Provide Sentrol/GE model #1076-D or approved equal.
- 11. Request-to-exit devices
 - a. Furnish and install motion request-to-exit sensors as shown on the drawings and as required. Devices shall mount directly above the each door. Utilize doors that have hardware which have integral request-to-exit switches as required. Coordinate with door hardware.
 - b. Provide DS 150i or approved equal with trim plate.
- 12. Auxiliary Power Supply
 - a. Provide auxiliary power supply(s) for REX sensors as required. Provide Altronix or approved equal.
- 13. Electric strike/magnetic locks power supply
 - a. Furnished by hardware installed and wired by Electrical SubContractor. Security Interface by IECS SubContractor.

- b. Fire Alarm interface by Electrical SubContractor.
- c. Provide coordination with door hardware contractor.
- d. Power supplies shall be interfaced to the fire alarm system as required.
- 14. Locking Devices (Electric strike/Magnetic locks/Electric locks/Electric Hinges locking hardware power supplies)
 - a. Furnished and installed by others. Wired by security Subcontractor.
- 15. Beacons
 - a. Provide blue security beacons as shown on the drawings. The unit shall wall or ceilings mount. The unit shall be 12/24 VDC and wired to the security management system.
- 16. Duress Stations
 - a. Provide remote duress red mushroom push button as shown on the drawings. The device shall be designed for high security applications and shall be vandal proof. Each duress button shall be wired to the USP for camera call-up and general alarm conditions. Each button shall report and be programmed independently of one another.
 - b. Provide Rauland HSS8 or approved equal.
- 17. UPS Units
 - a. Furnish and install UPS units for the complete Integrated Security systems as specified herein. UPS units shall be sized to support all equipment as specified herein for a minimum of 15 minutes. Provide calculations as required.
 - b. Each UPS units shall be located in the MDF room and IDF closets.
 - c. Material
 - 1) Each UPS shall have the following specifications.
 - 2) Up to .8 power factor (in watts)
 - 3) Independent battery pack chargers
 - 4) Simultaneous RS-232, USB and SNMP communications
 - 5) Monitoring and control software capable
 - 6) Front panel display with status indicators
 - 7) Hot swappable batteries
 - d. Provide Minuteman Endeavor ED series or approved equal.

2.10 INTRUSION ALARM SYSTEM

A. Intrusion Alarm Control Panel

- 1. Provide an intrusion system as required and as shown on the plans. The cost of monitoring the facility at a UL listed central station shall be included for a period of one year.
- 2. The intrusion alarm panel shall be fully integrated to the USP.
- 3. Provide all labor, materials, equipment, and services to perform all operations required for the complete installation and related work as shown in all contract documents.
- 4. All motion detectors, roof hatches and exterior doors shall report and be individually annunciated on the intrusion alarm system. For locations that are exterior access control doors, each door contact shall be double pole, double throw. One pole shall be wired to the intrusion alarm system and the other shall be wired to the access control system and programmed in accordance with the access control specification. Each exterior door shall be wired and individually reported to the intrusion alarm system.
- 5. Keypads shall be able to arm and disarm the intrusion alarm system
- 6. Once armed, any motion detector, door contact, or glass break shall both cause the audible sounder to sound and call the central station.

7. The control panel shall be capable of supporting Dynamic Host Communication Protocol (DHCP) Internet Protocol (IP) addressing.
 8. The control panel shall be capable of two-way network communication using standard Ethernet 10BaseT in a LAN, WAN, or Internet configuration.
 9. Provide an addressable intrusion alarm control panel complete with enclosure, power supply, and door lock.
 10. The panel must support up to 500 addressable points.
 11. The panel must be able to support 16 independent partitions.
 12. Provide with battery back up and battery harness for a minimum of 4 hours.
 13. Provide DMP500 series or approved equal.
- B. Intrusion Alarm Keypad
1. Provide 32 character platinum keypad as shown on the drawings.
 2. The keypads can be used to both arm and disarm the intrusion system.
 3. Provide DMP 7060A-P or approved equal.
- C. PIR Motion Detectors
1. Provide motion detectors of "home run" type as shown on the drawings. Sensors shall process their signals independently and shall have coverage patterns individually adjustable.
 2. Each PIR shall be wired to the intrusion alarm system.
 3. Provide long range detectors as shown on the plans and as required.
 4. Wiring connections shall be made in equipment cabinets. Conductors other than that of detector will not be allowed at each device. Detectors shall not be wired in series or with door contacts. There shall be no exposed wiring leading to/from detectors.
 5. Catalog, model and type numbers itemized herein for motion detectors are those of DMP.
 6. Detectors shall be mounted on ceiling type wiremold box.
 7. Fields of view that are directed at heat sources such as fans, radiators and other areas that may cause false alarms shall be masked out.
 8. Provide DMP models 6155LX, AP750, FX series, KX-08, and SX-360Z or approved equal.
 9. Provide one (1) addressable input module per motion, DMP 700 series or approved equal.
- D. Door Contacts/Switches
1. Provide recessed door contacts/switches as shown on the drawings. Contacts shall be 3/4 inch and have wire leads of sufficient length for splices to be made in wiremold box or mud type box located adjacent to door. Provide GE model #1078C or approved equal for interior doors. Provide DPDT contacts for all exterior doors, GE model #1076-D or approved equal.
 2. In event that circumstances prevent the use of recessed contacts in some locations, surface contacts may be used, subsequent to approval of Architect.
 3. Wiring for door contacts shall be concealed.
 4. Door contacts shall not be wired in series with exception of double doors which may be wired to panel as single door location.
 5. There shall be no splices in door frames or jambs. Door contact connections shall be made in wiremold or mud switch box located adjacent to door.
 6. Provide one (1) addressable input module per door contact.
- E. Overhead Door
1. Overhead door contact as shown on the drawings. Provide one (1) input module per device.

2. Provide Sentrol 2200 series or approved equal.
- F. Glass Break Detectors.
 1. Provide glass break detectors as shown on the drawings. Provide one (1) input module per device.
 2. Provide DMP 5812A or approved equal.
- G. Addressable Input Module
 1. Provide single input module devices for all non-addressable inputs (motions, door contacts, glass break detectors, duress button).
 2. Provide DMP 700 series or approved equal.
- H. Indoor Security Siren.
 1. Provide interior security siren(s) as shown on the drawings.
 2. Provide DMP 335 or approved equal.
- I. Outdoor Security Siren:
 1. Provide outdoor siren(s) as shown on the drawings. The horn shall draw 550ma at 12VDC.
 2. Provide Ademco 748LC or approved equal.
- J. Intrusion Alarm Panel Accessories and Modules
 1. Interface Adapter Module. Provide one (1) loop adapter bus card per system. Provide DMP 461 or approved equal.
 2. Loop/Zone expansion interface card. Provide a minimum of two (2) expansion cards per system. Provide a sufficient amount of zone cards to handle 574 points as required. Provide DMP 481 zone or approved equal.
 3. Dual Phone Line Module. Provide one (1) DMP 893A module or approved equal per system.
 4. Eight Input Module. Provide one (1) DMP 712-8 module or approved equal per system.
 5. Zone Expansion Module. The individual zone expansion module shall be used to monitor door contacts, motion detectors, glass break detectors, and other monitor points. Provide one (1) DMP 711 module or approved equal per device as required.
 6. Relay Output Module. Provide one (1) DMP 860 relay output module or approved equal per system. Provide with four (4) relays.
- K. Central Station Monitoring: Provide monitoring at a UL Listed central station for a period of one year.

2.11 EXTENDED SERVICE AND PREVENTATIVE MAINTENANCE AGREEMENT

- A. General
 1. The Systems Integrator shall supply a one year service and preventive maintenance agreement. The owner shall have the option to renew the agreement upon expiration.
 2. The agreement must be provided by the Systems Integrator which provided and installed the entire Integrated Security System.
 3. Equipment warranty shall be provided for a period of one year as described elsewhere within the specification.
 4. Remote monitoring of the Intrusion Alarm system at a UL Listed Central station.
 5. Access to 24/7/365 phone support. A technician will be

6. dispatched the next day of when the service call was placed.
7. A technician will be dispatched within 4 hours of when the call was placed for an emergency service call. Emergency service is defined as any one of the following: Video Server/ Video Workstation/Access Control Server/Access Control workstation fails, corridor camera/photo badge reader/card reader/intrusion panel or intrusion alarm keypad does not work.
8. A technician will be dispatched within 24 hours of when the call was placed for a normal service call.
9. Provide the client with 48 hours notice of arriving for all preventative maintenance work. And provide a one hour notice prior to arrival for all preventative maintenance work.
10. Provide the client a written report explaining the scope of the service call within 48 hours after completing the service call.

B. Preventative Maintenance

1. Upon a monthly basis:
 - a. Reboot all Video servers. Verify all cameras are properly reporting and recording. Verify all workstations are reporting and working properly.
 - b. Provide written report to end user stating the above is working properly.
2. Upon a quarterly basis:
 - a. Inspect CCTV Cameras. Verify Camera Field of View and Focus.
 - b. Verify Cameras are viewing the desired image by the customer.
 - c. Check System Alarm and Event Logs.
 - d. Verify Camera Programming, Naming, Image Quality Settings and Recording Settings.
 - e. Verify System is Recording and Note Retention Period.
 - f. Verify Recording Hard Drive Configuration and Status. Check for Drive Failures or Bad Sectors.
 - g. Verify Motion Detection Recording Settings. Verify all cameras are capturing the expected Motion Activity. Note any discrepancies.
 - h. Verify PTZ Control of applicable Cameras. Check Presets, Tours and Home Position Settings.
 - i. Verify all channels of the Video Encoder (s) are working properly.
 - j. Provide Microsoft Window updates to each Security Workstation.
 - k. Verify network switch utilization and network switch ports are functioning.
 - l. Check Access Control Panel / Controller Communications Status.
 - m. Check Access Control Panel / Controller Batteries. Note Battery Type, Voltage, Amp-Hour Rating and Date Code. Test and Note Battery Voltage.
 - n. Inspect Door Hardware for Operation, Damage & Mis-Alignment.
 - o. Inspect and Test Operation of Access Control Equipment at each Door [Card Readers, Door Contacts, REX & Door Release Push Buttons where applicable].
 - p. Test Operation of Ancillary Access Control Inputs and Outputs.
 - q. Check System Alarm and Event Logs. Attach a printed copy of the logs if applicable.
 - r. Verify Camera Call-Up upon Event / Alarm where applicable.
 - s. Verify Door Programming, Time Schedules, Access Levels and Door Unlock Schedules. Note programming operation.
 - t. Verify Photo Badge Reader and Workstation Photo-ID Call-up Operation.
 - u. Verify System Time of Day is configured and is synchronizing with a time server or consistent source.
 - v. Verify and Note Current Software Version and Device Firmware Versions.
 - w. Verify Client and Server Computer Hardware Specifications. Verify CPU, Memory

- & Network Utilization. Note Performance Stats. Perform Reboot of all Computers and verify system back-online and note any changes in performance stats.
- x. Verify Access Control System Database is configured for a regular back-up.
- y. Check each Intrusion motion detector, intrusion door contact, glass break device, duress button and keypad to verify its working properly.
- z. Provide written report to end user stating the above is working properly.
- 3. On an annual basis:
 - a. Notify the owner of any new USP software upgrades/updates/patches which are available. Install upgrades/updates/patches as approved by the owner.
- 4. Hardware Support
 - a. The Systems Integrator shall perform scheduled maintenance services on all systems and equipment as specified in this section.
 - b. Components and parts that are found to be defective, have failed operationally or which exhibit signs of near term failure will be identified during each preventive maintenance inspection or test. If the component or part is covered under a current Systems Integrator or factory warranty, said part or component will be replaced at no charge to CUSTOMER including labor during normal business hours.
 - c. For any equipment requiring repair or replacement that is not covered, an estimate will be prepared and submitted for approval on a reimbursable basis and repair authorization shall be issued in writing by an authorized representative of the CUSTOMER before proceeding with the work.
- 5. Response Time
 - a. Should an emergency arise, the Systems Integrator personnel will assess the situation either by phone or remote diagnostics, or both, and will determine the required course of action with the CUSTOMER.
 - b. On-Site Response Time: If it is determined that a site visit is required, the Systems Integrator personnel will arrive at the affected premises within four (4) hours of the request of the CUSTOMER.
 - c. If the resolution of the emergency service call requires the Systems Integrator to provide service for equipment that is not listed in this specification section, CUSTOMER will be liable for charges and expenses prevailing for such service.
 - d. Emergency Service will be provided during the following periods.
 - 1) Provide Emergency Service Monday through Friday 8:00 AM – 5:00PM excluding evenings and weekends, city, state, federal and Systems Integrator observed holidays at no additional charge to the base annual service fee. Labor for travel time is included under this Agreement. The Systems Integrator will provide a response time as stated and agreed to above. Emergency Service requested by the CUSTOMER to be provided outside of the above stated times will be reimbursed by the CUSTOMER as shown below.
 - e. Emergency Service during the following periods is not included.
 - 1) Emergency Service Monday through Friday 5:00PM – 8:00AM, weekends, city, state, federal and Systems Integrator observed holidays are not included. Emergency Services provided under this scope will be reimbursable by the CUSTOMER to the Systems Integrator at then current Systems Integrator published service labor rates and standard service charges (Minimum Labor Charge, Vehicle Charges, Round Trip Travel Time, Mileage).

2.12 IESS INTEGRATION

- A. Interface and Integration between Access Control, CCTV, Intrusion Alarm, Public Address, and Telephone System.
1. Access Control System Keypads, and Readers shall provide ability to Arm and Disarm the entire Intrusion Alarm System or specific zones.
 2. Access Control System Keypads, and Readers shall provide ability to Arm and Disarm any individual areas in the Intrusion Alarm System.
 3. Intrusion Alarm System devices (i.e. motion sensors, door contacts, glass break detectors) shall be graphically displayed on the Access Controls System's browser based Graphical Designer software for display on associated PC Workstation.
 4. Arm, Disarm & Alarm status condition of the Intrusion Alarm System devices (i.e. motion sensors, door contacts, glass break detectors), shall be graphically displayed on the Access Controls System's built-in Graphical Designer software for display on associated PC Workstation.
 5. When Intrusion Alarm System devices (i.e. motion sensors, door contacts, glass break detectors) are in alarm, provide ability to turn-on or go to full motion video, the CCTV Camera Recorder in associated area.
 6. Activate alarm siren signal over Public Address speakers when Intrusion Alarm System is in alarm by providing line level output for Public Address System.
 7. When Access Control System Keypads, or Readers are used, provide ability to turn-on or go to full motion video, the associated CCTV Camera Recorder.
 8. When door release is detected on entry or exit, provide ability to turn-on or go to full motion video, the associated CCTV Camera Recorder.
 9. CCTV Camera devices and locations shall be graphically displayed on the Access Controls System's built-in Graphical Designer software for display on associated PC Workstation.
 10. When exterior door intercom station is activated, provide ability to turn-on or go to full motion video, the associated CCTV Camera Recorder.
 11. Access Control System Keypads, Readers, and Door Lock locations shall be graphically displayed on the Access Controls System's built-in Graphical Designer software for display on associated PC Workstation.
 12. Special Entry: If a person needs a one-time entry to the facility for a particular time and day, a Access Control Keypad entry code number can be given to that person that will only work for the specific time frame; in addition, the code can automatically disarm associated intrusion alarm zone or zones in the system.
 13. Emergency Codes can be used via Access Control System Keypad Entry, with capabilities to automatically notify authorities of a emergency situation, a hostage type entry.
 14. Photo ID Bagging Capabilities Built-in to Access Control System, allowing owners the capability to develop their own Photo ID Badges.
 15. Access Control Systems can interface with LAN's & WAN's to provide seamlessly integrated solutions when additional facilities add access control solutions.
 16. When Exterior Door Intercom Stations are properly interfaced to the Telephone System Display Telephones for unique call-in ID and two-way communications, and the telephone system provides output closures (one for each controlled door) when "door release codes" are entered via the telephone's keypad, provide ability to interface these door release code closures to Access Control System for release of each associated door.
 17. The CCTV system shall provide "Recording-on-Motion" feature for every camera in the CCTV System. Only recording when the system detects motion in the view of each camera.
 18. Provide interface port for interfacing to Fire Alarm System.
 19. Provide interface port for interfacing to Elevator Door Access.

PART 3 - EXECUTION

3.01 GENERAL

- A. Verify the exact location prior to bid of all items that may be indicated and determine exact location of all electrical items that are not indicated on the Drawings.
- B. Include the cost of all work including sub-letting of any work that may be required to complete the work indicated in order to avoid work stoppages and jurisdictional disputes. The work to be sublet shall conform with precedent agreements and decisions of record. Jurisdictional assignment shall be a responsibility under this Section's contractual obligation.
- C. Do not install equipment and materials which have not been reviewed by the Architect. Equipment and materials which are installed without the Architect's review or without complying to comments issued with the review shall be removed from the project. No payment will be made for unapproved or removal if it is ordered removed. The Installer shall be responsible for any ancillary costs incurred because of its removal and the installation of the correct equipment and materials.
- D. Obtain detailed information on installation requirements from the manufacturers of all equipment to be furnished, installed or provided. At the start of construction, check all Contract Documents, including all Drawings and all Sections of the specifications for equipment requiring electrical connections and service and verify electrical characteristics of equipment prior to roughing.
- E. Equipment and systems shall not be installed without first coordinating the location and installation of equipment and systems with the Construction Manager, AHJ and all other Trades.
- F. Any and all material installed or work performed in violation of above requirements shall be re-adjusted and corrected by the Installer without charge.
- G. Refer to all Drawings associated with the project, prior to the installation or roughing-in of the electrical outlets, conduit and equipment, to determine the exact location of all outlets.
- H. After installation, equipment shall be protected to prevent damage during the construction period. Openings in conduits and boxes shall be closed to prevent the entrance of foreign materials.
- I. Home runs indicated are not to be combined or reduced without written consent from the Architect.
- J. All connections to equipment shall be made as required, and in accordance with the approved submittal and setting drawings.
- K. Delivery, Storage and Handling:
 - 1. Deliver, store, protect and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
 - 2. Deliver equipment in individual shipping splits for ease of handling, mount on shipping skids and wrap for protection.
 - 3. Inspect and report concealed damage to carrier within specified time.
 - 4. Store in a clean, dry space. Maintain factory protection or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. Heat enclosures to prevent

condensation. Meet the requirements and recommendations of NFPA 70B and the Manufacturer. Location shall be protected to prevent moisture from entering enclosures and material.

5. Handle in accordance with NEMA and the Manufacturer's recommendations and instructions to avoid damaging equipment, installed devices and finish.
6. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passage through restricted areas during transportation, the Manufacturer shall be required to brace the equipment suitably to insure that the tilting does not impair the functional integrity of the equipment.

L. Site Observation:

1. Site observation visits will be performed randomly during the project by the Engineer. Reports will be generated noting observations. Deficiencies noted on the site visit reports shall be corrected. All work shall comply with the Contract Documents, applicable Codes, regulations and local Authorities whether or not a particular deficiency has been noted in a site visit report.
2. Be responsible to notify the Engineer and AHJ ten working days prior to closing in work behind walls, raised access floors, ceilings, etc., so that installed work can be observed prior to being concealed.
3. Work concealed prior to observation and correction of deficiencies shall be made accessible for review at the discretion of the Architect. Bear all costs for allowing worked to be reviewed.
4. Areas shall stay accessible until deficiencies are corrected and accepted. Notify the Architect when all deficiencies are corrected. Return reports with items indicated as corrected prior to re-observation by the Architect.

M. Change Orders, Modifications, Revisions and Directives:

1. When change orders, modifications, revisions or Architect's Directives are issued or authorized, provide the required additional material, equipment, personnel and workers to prevent delays in the work, and to complete the work within the time limit of the Contract unless a specific time extension is requested with the change and accepted. Include costs for expediting deliveries where required.
2. Requests for additional compensation shall be submitted broken down and associated by item, tasks and Drawing or sketch number with material and labor costs, so quantities can be easily verified.
3. Requests shall be properly and adequately identified so the scope of work can be clearly determined. Indicate who originated change in work.
4. Submit on all credits broken down as requested for adds. Credits shall be separately identified and accounted for. Do not indicate as net changes with adds.
5. Unit costs for labor and material shall be equal for adds, deletes and credits.

3.02 WORK

- A. Loose materials shall not be stored on-site. A "gang box" is acceptable to be placed in a location agreeable to the Owner and the Construction Manager. The Installer is responsible for all equipment and materials and for their delivery until the system is accepted by the Owner.
- B. A trailer may be used for the storage of materials to be located on the Owner's property at a location designated by the Owner and the Construction Manager. Such on-site storage shall be kept locked by the Installer. Security for the trailer and its contents shall be strictly the

responsibility of the Installer.

- C. Protect existing in spaces where work is being performed to protect it from damage and from the accumulation of dirt.
- D. Any ceilings, walls, floors, furniture, equipment, furnishings, etc., damaged by the work of this Section shall be replaced, or at the Owner's option, repaired with similar materials, workmanship and quality.
- E. This contractor is responsible for coring through any existing firestopping where using sleeves that have been firestopped to run new wiring. Provide new firestopping where firestopping was removed for new wiring.
- F. Work includes field survey of existing conditions, systems, equipment and tracing of existing circuits in order to determine scope of work.
- G. Clean and touch up all equipment, materials and work sites at the completion of work in each area.
- H. Certain portions of the work area may be occupied during construction. Determine which areas and schedule work accordingly and include necessary premium time.
- I. Make sure necessary provisions to provide continuous service of all existing systems throughout all occupied areas.

3.03 EQUIPMENT RACKS, CABINETS AND BRACKETS

- A. Securely mount equipment racks, cabinets and wall mounted relay brackets to the building structure. Proper supports such as 3/8 in. lag screws and expansion anchors shall be used. Proper quantity of supports shall be utilized. Dry wall screws and other types of supports not specifically approved to support equipment are specifically prohibited. Submit mounting supports for approval before installation.
- B. Position racks, cabinets, and wall mounted relay brackets in order to have minimum 3-foot clearance for easy access. Equipment racks, cabinets and relay brackets mounted on or against walls shall have 3-foot clearance in front of deepest component. Free standing equipment racks and cabinets shall have 3-foot clearance in front and rear of deepest components. Provide 3-foot clearance between free standing equipment racks or cabinets and any other obstruction to allow access from front to rear of rack or cabinet for maintenance.

- C. The Electrical Subcontractor shall provide cable tray over each rack and cabinet as required to facilitate a neat and orderly installation of cables and to secure the top of the racks to the structure. Cables shall drop straight down to equipment racks. Cable trays shall be secured at both ends to the structure and connected together as required for a complete contiguous installation. Utilize listed supports to support the cable tray to the building structure as well as the equipment rack and cabinet. Submit mounting supports for approval by Engineer and AHJ before installation.
- D. Install terminating components such as patch panels (UTP, Fiber optic); cable management, etc. into the racks, cabinets and wall mounted relay brackets.
- E. Patch Panels: Mount patch panels onto the rack(s) in top-to-bottom fashion with the first patch panel mounted at the top of the rack. Uniquely label each patch panel according to the numbering convention outlined in the SECTION on labeling. Each port shall also have color coded identifiers. Refer to details on the Drawings.
- F. Cable Management: All cables shall enter the wiring closet to within the equipment racks and/or brackets. Secure the bundle(s) to the rack strain relief and wire management behind the patch panels and cross connect block panels. Install horizontal and side-mounted vertical cable management panels and brackets for routing and management of patch cables. Maintain EIA/TIA and BICSI standards on bundling, supporting and bend radii.
- G. Once the cabling system has been installed and terminated, install all active components and surge protected power strips into the racks, cabinets and wall mounted relay brackets.
- H. Surge Protected Outlet Strips: Mount UPS and surge protected outlet strips per Manufacturer's directions. Refer to details on the Drawings for mounting location.

3.04 TERMINATIONS

- A. All copper or fiber conductors of every cable shall be completely terminated at both ends.

3.05 CABLE PATHWAYS

- A. Provide all equipment and cabling for a complete installed operating system. In general, pathways, outlet boxes and grounding are provided by the Electrical Subcontractor. CAT 6A Ethernet cables for all CCTV locations are provided by the I.T. Sub-Contractor.
- B. All pathways provided under this Section shall comply with fill capacities as per Code, EIA/TIA 569A and BICSI.
- C. Cable bending radius shall not be less than minimum required by EIA/TIA and BICSI.
- D. Cabling installed concealed shall be supported from the building structure (e.g. cable trays, snake tray) hook and loop (velcro).
- E. Cables shall be installed no closer than 12 inches (305mm) to electrical equipment and wiring. When cables are required to cross power wiring, they shall only do so perpendicular to the power wiring. Telecommunications cabling and power wiring shall only cross each other the minimal

number of times as required due to building design limitations.

- F. Clearances: Clearances between cabling and other building systems as required by EIA/TIA 569A and BICSI shall be maintained throughout the building.
- G. All cables shall be installed in a neat and workman-like manner. Cables shall be installed parallel and perpendicular to building elements.
- H. Provide expansion fittings and adequate cable slack at all building expansion joints.
- I. Fire/smoke seal all conduits, raceways, sleeves, slots etc. where cables pass from one location to another, provided by electrical subcontractor.

3.06 CABLE SUPPORTS

- A. Provide strain relief hardware for backbone cables at each floor level as they pass from one floor to the next.
- B. Provide hook and loop (Velcro) cable wraps at all panels, equipment racks and cabinets. Cable ties are specifically prohibited.
- C. Hook and loop (Velcro) cable wraps shall be used. Cable-ties are specifically prohibited for fiber optic cables.
- D. When pathways are not provided or specified, provide hook and loop (velcro) supports from the building structure as required for cable runs to the cable drop location. Maximum distance between supports shall be three feet. Maximum number of cables per support shall be thirty. Provide additional supports as required when cable quantities exceed thirty and to maintain required bending radius of cables. Cables installed exposed or in areas subject to abuse (below 10 feet (3m) above finished floor) or in accessible areas shall be installed in conduit.
- E. All cables shall be supported directly from building structure. Under no circumstance shall cable be installed using cross bracing, plumbing/sprinkler pipes, ceiling systems or any other system that is not a specifically approved method to independently support cables. Cables shall not be allowed to rest on ceiling tiles, duct work, piping, etc. Supports shall be provided as required in order for cables to avoid contact with any other building system. Bundle cables in groups by room and floor.

3.07 CABLE PROTECTION

- A. Provide bushings in all metal studs and the like where cables will pass through. Bushings shall be of two (2) piece construction with one piece inserted through the opening and the second piece locking it into place. Single piece bushings with locking tabs or friction fit are specifically prohibited.
- B. Cables to be installed in existing enclosed open bays or furred spaces where conduit stubs are not provided shall be protected from chafing or any damage. The Installer shall verify that the warranty shall not be violated before installing any cabling in these locations.

- C. Provide cutting, coring, sleeves and bushings and seal as required at all penetrations.
- D. Cables damaged during installation or construction shall not be repaired. They shall be completely replaced with new cable.

3.08 INSTALLATION

- A. All cabling shall be installed in conduit where indicated on plans, or shall be installed open using other methods, approved by city electrician and engineer, such as cable tray & snake tray.
 - 1. Install wiring, per manufacturers recommendations.
 - 2. All wiring shall be new, concealed in pipe where exposed.
 - 3. Install wiring for detection and signal circuit as specified. Make wiring connections to new or existing door hardware devices as required.
- B. All conduits, raceways, innerduct, etc. shall have pull strings remaining after cable is pulled.
- C. Impedance and Level Matching:
 - 1. Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
- D. Control Circuit Wiring:
 - 1. Install control circuits in accordance with NFPA 70 and as indicated. Provide number of conductors as recommended by system manufacturer to provide control functions indicated or specified.
 - 2. All housings are to be located as specified and shown on drawings.
 - 3. Make installation in strict accordance with approved manufacturer's drawings and instructions.
 - 4. The Installer shall provide necessary transient protection on the AC power feed, all station lines leaving or entering the building, and all central office trunks. All protection shall be as recommended by the equipment supplier and referenced to earth ground.
- E. Splices, Taps, and Terminations:
 - 1. Make splices, taps and terminations on numbered terminal punch blocks in junction, pull, and outlet boxes, terminal cabinets and equipment enclosures.
 - 2. Identification of Conductors and Cables:
 - a. Use color coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams.
- F. Weatherproofing:
 - 1. Provide weatherproof enclosures for items to be mounted outdoors or exposed to weather.
- G. Aiming and Focusing
 - 1. Contractor shall meet with the user and Aim/Focus each camera to the satisfaction of the user.

3.09 GROUNDING

- A. General:

1. The Telecommunications systems comprising of cable tray, snake tray, equipment cabinets, racks and non-current carrying metallic parts shall be grounded according to the Massachusetts Electrical Code.
2. In general, the grounding shall be as specified, as indicated on the Drawings and as required by the Electrical Code.

B. Methods:

1. Provide equipment grounding connections for integrated sound, voice and video systems as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.
2. Ground equipment, conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.
3. The installer shall provide all necessary transient protection on the AC power feed and on all station lines leaving or entering the building.
4. The installer shall note in his system drawings, the type and location of these protection devices as well as all wiring information.
5. The installer shall furnish and install a dedicated, isolated earth ground from the central equipment rack and bond to the incoming electrical service ground buss bar.

C. Telecommunications Grounding

1. Raceways including wireways, conduits, cable trays, snake tray, etc. installed for low voltage or fiber optic cabling shall be made electrically continuous for grounding purposes. Provide hollow braided copper jumpers between sections equal to Belden No. 8669 (60A Ampacity). Provide equal impedance conductor for aluminum raceway.
2. Bond raceways to the ground bus located in the equipment cabinet. Bond raceways in each room they terminate in.

D. Telecommunications Equipment Bonding & Grounding

1. Provide grounding and bonding as required by EIA/TIA-607 standards, codes and the equipment manufacturers.
2. Make final grounding conductor connection to cabinet around bus.
3. Each individual piece of equipment shall have an individual grounding conductor to the ground bus within the cabinet.
4. All equipment shall have bonding jumpers between them (i.e. between cable tray, snake tray and equipment rack, etc.).
5. Equipment integral to an equipment rack (i.e. shelves, panels, cable management, etc.) shall be considered bonded.
6. Equipment that is not integral to an equipment rack (i.e. shelf mounted electronic equipment, cable tray, snake tray, etc.) require individual bonding jumpers between the equipment and the rack.
7. Properly clean and prepare all surfaces for a complete bonding and grounding termination.
8. Install grounding bus in all equipment racks and cabinets.

3.10 SLEEVING AND BUSHINGS

- A. Raceways and openings shall be laid out in advance to permit their provision in the work. Sleeves and raceway shall be set before new masonry is constructed. Any extra work required where sleeves or raceways have been omitted or improperly placed shall be

performed at the expense of the Installer which made the error or omission, including coring.

1. Existing Construction: Where raceways and cable pathways must pass vertically through existing construction, coring shall be located as per the guidelines shown on the drawings.
- B. Provide sleeves for raceways, busways, snake trays and cable trays penetrating floors, fire walls, or smoke partitions. Install approved material to provide for fire stop.
- C. Provide waterproof seals inside and outside raceway when penetrating from the exterior or underground.
- D. Except where specified otherwise sleeves shall be made of galvanized metal to finish flush with building finish lines.
- E. Provide acoustic sealer in sleeves between occupied spaces.
- F. Sleeves installed in floors shall extend ten inches above the finished floor unless specifically indicated otherwise. Sleeves for busways shall extend four inches (100mm) above the floor.
- G. Provide sleeves in masonry construction and in full height (slab to slab) walls.
- H. Provide sleeves for any openings requiring fireproofing.
- I. Bushings in all conduits shall be provided by the Electrical Subcontractor in all metal studs and other openings where cables will pass through. Bushings shall be of two-piece construction with one piece inserted through the opening and the second piece locking it into place. Single piece bushings with locking tabs or friction fit are specifically prohibited.

3.11 INTEGRATED SECURITY SYSTEM TESTING

- A. Security Management System
 1. Test in accordance with manufacturer's security management systems testing procedures.

3.12 TRAINING

- A. As a minimum training sessions shall consist of the following:
 1. General project information and review shall be by the General Foreman or Superintendent of the Trade.
 2. Specific system training shall be by a Factory Trained Representative.
 3. Provide a complete review of the project and systems including, but not limited to, the following:
 - a. In a classroom environment review each Record Drawing (use of typical is acceptable).
 - b. Note equipment layouts, locations and control points.
 - c. Review each system.
 - d. Review system design operation and philosophy.
 - e. Review alarms and necessary responses.
 - f. Review standard troubleshooting techniques for each system.
 - g. Review areas served by equipment.

- h. Identify color codes used.
 - i. Review features and special functions.
 - j. Review maintenance requirements.
 - k. Review operation and maintenance manuals.
 - l. Respond to questions (record questions and answers).
- 4. After classroom training, walk the entire project, review each equipment room and typical locations. Explain equipment and proper operation.
- B. During the instruction period the Owner and Maintenance Manual shall be used and explained.
- C. The Owner and Maintenance Manual material shall be bound in 3-ring binders and indexed. On the edge of the binder provide a clear see-through plastic holder with a typed card indicating the Project name, the Architect's name, the installer's name and the Volume number (e.g., Vol. No. 1 of 2).
- D. Provide name, address and telephone number of the manufacturer's representative and service company for all items supplied so that the source of replacement parts and service can be readily obtained.
- E. Include copies of manufacturers and installer's warranties and maintenance contracts and performance bonds properly executed and signed by an authorized representative.
- F. Include copies of all test reports and certifications.
- G. Provide 8 hours of video taped training broken up into (2) 4 hour sessions. The training shall be done once the system is complete and operational and all programming is complete. The training shall include step by step instructions of the sequence of operations at each door type, moves adds, changes, and use of all supplied IESS equipment.
- H. Contractor shall be required to provide professionally video recorded training sessions with Owners staff and provide one copy to the Owner.

3.13 ACCEPTANCE DEMONSTRATIONS

- A. Prior to the Acceptance Demonstration, the installer shall issue a letter stating that the system has been installed and tested to meet the specifications noted herein and that the system is 100% functional and operational and ready for use.
- B. Systems installed under this Section shall be demonstrated to the Owner and Architect. Demonstrations are in addition to necessary testing and training sessions. Notify all parties at least 7 days prior to the scheduled demonstration. Schedule demonstrations in cooperation with and at times convenient to all parties and so as to not disturb ongoing activities.
- C. Systems shall be tested prior to the demonstrations and each system shall be fully operational and tested prior to arranging the Acceptance Demonstration. Final payments will be withheld until a satisfactory demonstration is provided for all systems indicated or requested.
- D. If the demonstration is not totally complete, performing all functions, features and connections or interfaces with other systems, or if there is a failure during the demonstration, additional

demonstrations shall be arranged. Provide and pay for all costs, labor and expenses incurred for all attendees for each additional demonstration required for acceptance and demonstration of complete system operation.

- E. Demonstrations shall be scheduled in ample time to complete all activities prior to final acceptance and Owner occupancy. Demonstrations shall take place at least 45 days prior to the scheduled project completion date and 45 days prior to owner's use and occupancy.
- F. The city electrician shall be trained and factory certified to operate the systems.
- G. As a minimum, provide demonstrations for systems indicated under "Work Included" under Part One of the Specifications. Provide demonstrations of additional systems as requested by the Owner, or City Electrician.

3.14 PROJECT OWNER COORDINATION

- A. Prior to Substantial Completion of the project and in ample time to address and resolve any coordination issues, request and arrange meetings between the Owner, Owner's Vendors and Consultants, Architect and Construction Manager to discuss the Scope of Work for each system being provided and the interface required for a fully functional and operational system upon project completion. Initial meetings shall be scheduled three months prior to the scheduled Substantial Completion date or as soon as Submittals are submitted and reviewed for projects with shorter schedules.
- B. At these meetings the required interface with the Owner shall be reviewed, requests for information required to complete programming or for coordination shall be presented and system operation and philosophy shall be discussed.
- C. Additional meetings shall be held as requested by any party so that all issues are resolved and with the goal and intent being that all systems are fully operational and functional upon project Substantial Completion and that the responsibility for all components required is clearly established.

3.15 CLEANING UP

- A. Upon completion of all work, and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.
- B. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned and plated surfaces polished.
- C. Repair damage to finish surfaces resulting from work under this Section.
- D. Remove material and equipment from areas of work and storage areas.
- E. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.
- F. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.

3.16 PROJECT CLOSEOUT

- A. Provide close out submittals as required herein and in SECTION 017700 – CLOSEOUT PROCEDURES, SECTION 017832 - OPERATION AND MAINTENANCE DATA and SECTION 017839 – PROJECT RECORD DOCUMENTS including but not limited to the following close out submittals.
 - 1. Operation and Maintenance Manuals
 - 2. Record Drawings.
 - 3. Test Reports.
 - 4. Extra Materials.
- B. Obtain written receipts of acceptance close out submittals submitted. Receipts shall specifically detail what is being delivered (description, quantity and specification section) and shall be dated and signed by firm delivering materials and by the Owner.
- C. All sketches, drawings, and charts herein are for the purpose of providing for specifications in a simplified format. Errors and omissions in such does not relive the Contractor of the responsibility for providing a fully complete, secure and properly operating IESS suitable for the intended use. Bidders must obtain a complete set of Project Drawings and Specifications to determine the full scope of work. In case of conflict the Project Drawings and Specifications shall prevail.

END OF SECTION 280000

SECTION 31 00 00
EARTHWORK

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

- A. Work Included: Furnish all labor, supervision, equipment, supplies, and materials and perform all operations necessary to complete the work of this Section, including but not limited to the following:
 - 1. Earth and rock excavation of all types.
 - 2. Filling to raise grades, compaction, and grading.
 - 3. Sheet piling, shoring, and dewatering of excavations and trenches.
 - 4. Excavation and backfill for removal, relocation, and abandonment of existing underground utilities, foundations, and below-grade structures.
 - 5. Preparing subgrades for structures, walls, pavers, utilities, sidewalks, and landscaping.
 - 6. Providing, processing, placing, and compacting earth and aggregate fill materials.
 - 7. Removal, hauling, stockpiling, re-handling, and placement of materials.
 - 8. Off-site disposal of excess soil and rock materials which are considered not to be viable for on-site re-use.
 - 9. Preserving and protecting existing site features to remain, and new site improvements during the course of the work.
- B. Related Work: The following items are not included in this Section and are specified under the designated Sections:
 - 1. Section 31 10 00, SITE CLEARING AND PREPARATION.
 - 2. Section 31 23 19, DEWATERING.
 - 3. Section 31 25 00, EROSION AND SEDIMENT CONTROLS.
 - 4. Section 31 50 00, SUPPORT OF EXCAVATION.

- C. Subsurface Data and Site-Specific Information: Refer to Section 00 31 32, SUBSURFACE DATA for information on site subsurface conditions. The Contractor shall be aware of the following as pertaining to the work of this Section:
1. Unsuitable foundation soils including existing undocumented fill are present at the site. All unsuitable foundation soils, as determined by the Engineer upon visual observation, shall be completely removed from beneath new structures and slabs and replaced with Structural Fill to reestablish to required line and grade. The removal and replacement area shall extend outside of the structure footprint to include the zone-of-influence (ZOI), as defined herein. Removal of unsuitable foundation soils beyond the specified lines and grades shall follow the procedure for Additional Excavation, as defined herein.
 2. Temporary excavation support may be required depending on excavation depths and if excavations need to approach the ZOI beneath existing structures, utilities, or other site features.
 3. Required excavations will likely expose variable soil conditions including, but not limited to, sand, sand and gravel mixtures, and silty sand. Soils containing more than trace amounts of fines (silt and/or clay) may be particularly susceptible to softening and disturbance by construction activity, especially during wet or freezing weather. Subgrade protection is the responsibility of the contractor, and special precautions and protective measures appropriate for the weather conditions during construction shall be used to preserve the integrity of subgrades. Disturbed subgrades shall be repaired at the sole expense of the Contractor.
- D. Field and Laboratory Testing: The Owner shall retain the services of an independent construction materials testing agency to conduct the laboratory analyses and field testing of soil materials required by this Section. Contractor shall coordinate locations and types of field tests to be performed with the Owner's Engineer and cooperate in every way with the Owner's Engineer and testing laboratory during field testing and with collection of soil samples for laboratory testing.

1.3 EXAMINATION OF SITE AND DOCUMENTS

- A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.
- B. Plans, surveys, measurements and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed its own conclusions as to the full requirements of the work involved.

1.4 DEFINITIONS

- A. Backfill and Fill Materials: Natural soil and/or rock and processed aggregate materials used in construction as specified herein.
- B. Structures: Buildings, concrete slabs, foundations, equipment pads, manholes, below grade vaults, and equipment capsules.
- C. Unsuitable Foundation Soils: Existing on-site soils determined by the Engineer to not be suitable for the proposed overlying site improvement or structure, and designated or reasonably

understood to classify as, or contain, any of the following: topsoil, undocumented fills, organic silt or clay, peat, vegetation, wood or roots, porous biodegradable matter, disturbed soils, artificial or organic debris, contaminated media, snow, ice, or refuse.

- D. Subgrade: The bottom surface of a trench or excavation extending to the underside of site improvements, including specified bedding materials, for building foundations and slabs, structures, pavement subbase, or other surfacing material.
- E. Pass: A single complete coverage with compaction equipment over the entire surface of an exposed lift or subgrade being compacted.
- F. Zone-of-Influence (ZOI): The horizontal plane extending away from the outside bottom edge of the footings, slabs, structures, and utilities a distance of two feet, then by a connecting plane that slopes down and away from the foundation at a maximum 1H:1V slope.

1.5 REFERENCES

- A. The following standards are applicable to the work of this section to the extent referenced herein.

- 1. ASTM International (ASTM):

- a. ASTM C117 Standard Test Method for Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing.
- b. ASTM C136 Method for Sieve Analysis of Fine and Coarse Aggregates.
- c. ASTM D1140 Standard Test Method Particle Size Analysis of Soils Standard Test Methods for Determining the Material Finer than No. 200 Sieve in Soils by Washing.
- d. ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³) (2700 kN-m/m³)
- e. ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soils and Rock by Mass
- f. ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- g. ASTM D2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
- h. ASTM D4318 Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils
- i. ASTM D4643 Standard Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating
- j. ASTM D4959 Standard Test Method for Determination of Water Content of Soil by Direct Heating
- k. ASTM D6913 Standard Test Method Particle Size Analysis of Soils
- l. ASTM D6938 Test Methods for Density of Soil and Soil-aggregate in Place by Nuclear Methods (Shallow Depth).

- 2. Commonwealth of Massachusetts Department of Transportation (MassDOT) Standard Specification for Highways and Bridges.

3. Code of Massachusetts Regulations (CMR) 310 CMR 40.0000 Massachusetts Contingency Plan.
4. Code of Massachusetts Regulations (CMR) 520 CMR 14.00 Excavation & Trench Safety Regulation.
5. Massachusetts Building Code 780 CMR Ninth Edition, 2017.

1.6 SUBMITTALS

- A. Material Test Reports: From a qualified independent testing agency with testing completed within 60 days of submission that indicates and interprets test results for compliance of the following with requirements indicated:
 1. Classification according to ASTM D 2487 and particle size distribution based on ASTM D6913 of each on-site and borrow soil and/or fill material proposed for fill and backfill.
 2. Laboratory compaction curve according to ASTM D 1557 for each on-site and borrow soil and/or fill material proposed for fill and backfill.
- B. Earthwork Operations Plan: Prior to commencing earthwork activities, submit a work plan describing the earthwork operations including: frequency and locations of tests and inspections; equipment list, including excavation, material processing, grading, compaction and moisture control equipment; locations and methods of excavating; handling, and stockpiling (if applicable) of excavated material, including methods to keep materials from various sources separated; drainage and dewatering (if required). No work shall be performed until this plan has been approved by the Owner's Engineer.
- C. Supply and Quality Control Inspection Results: Submit the results of all sources of supply and quality control inspections and tests. Submittals reviewed beyond the second rejection (or required submittal) shall be provided at no cost to the Owner and shall be reviewed by the Owner's Engineer at the Contractor's expense. No work shall be performed until the Owner's Engineer has reviewed the source of supply. It is the Contractor's responsibility to submit the Supply and Quality Control Inspection Results in a timely manner to assure the project's workflow.
 1. Backfill Materials: Submit 20-pound samples for each backfill material from each proposed source including on-site materials. Samples of off-site soil borrow for submission shall be collected in the presence of the Owner's Engineer so that the Owner's Engineer has the opportunity to see each borrow material at the source.
 2. In addition, a certification statement and analytical results shall accompany each physical sample of earth material to be imported onto the site. At a minimum the certification shall state the point of origin, its past usage, name of the qualified firm and analytical laboratory that performed the material sampling and testing, and that the material is free of contaminants and do not contain contaminants that exceed the reportable concentrations (RCS-1) of the MCP. The certification shall include representative sample analysis from each point of origin of backfill to be used on the site. The sample(s) shall be analyzed by a certified laboratory for at a minimum total metals (EPA priority pollutant metals), volatile organic compounds (EPA Method 8260), semi-volatile organic compounds (EPA Method 8270),

petroleum hydrocarbons (EPA Method 8100), and Total PCBs and pesticides (EPA Method 8081 and 8082).

- a. All sampling of soils for chemical testing shall be performed by a person experienced in sample collection and shall be either: 1) a Licensed Site Professional registered in the Commonwealth of Massachusetts; 2) a Professional Engineer registered in the Commonwealth of Massachusetts; 3) a professional Geologist registered in the Commonwealth of Massachusetts; 4) a certified groundwater/environmental professional; or 5) an authorized representative of the one of the persons listed above. Samples of each material shall be submitted to a chemical analytical laboratory, certified by the Massachusetts Department of Environmental Protection.
 - b. Material shall not contain asbestos.
3. Submit additional samples and geotechnical and analytical test data and certifications for every 1,000 cubic yards (every 500 cubic yards for moisture density curves) of material imported or reused on-site or anytime consistency of material changes in the opinion of the Owner's Engineer. Submit associated chemical laboratory data on the imported materials throughout the course of the Work, if requested by the Owner's Engineer, to evaluate the consistency of the source or process, at no additional cost to the Owner.
 4. Information identifying the name of the accredited field and laboratory soil testing subcontractor proposed for documenting conformance of earthwork activities. Include examples of typical field and laboratory test result documentation from the subcontractor that are proposed for use the project. In addition to test results, the report documentation shall include the location and elevation of all tests, materials tested, a description of methods and equipment used, compaction requirements, and conformance or non-conformance. All measuring and testing equipment (MTE) used at the site shall have documentation certifying the MTE has been calibrated within the last year (or sooner if required by subcontractor quality procedures). Calibration certificates shall be provided to the Engineer at least one week prior to MTE use on site.
 5. During Construction, submit written confirmation from the independent construction materials testing agency of fill lift thickness, in-place soil moisture content, and percentage of compaction to the Owner's Engineer before placing the next lift or constructing foundations or structures.

1.7 QUALITY CONTROL

- A. The Owner shall engage a qualified, independent construction materials testing agency to perform quality control testing and inspections. Compaction testing shall be performed at the minimum frequency specified herein.
- B. The Contractor shall assume full responsibility for coordination and providing timely and safe access for quality control inspection and testing. The Contractor shall give sufficient notice to the Engineer to permit the witnessing of the inspections or tests.
- C. Source of supply. No earthwork materials will be accepted on the site without written approval of submittals from the Owner's Engineer.
- D. The Owner's Engineer reserves the right to observe earthwork operations at any time during the execution of the work.

- E. Notification Point: The Contractor shall give the Owner's Engineer two days' notice in advance of quality control tests and inspections.

1.8 EXCAVATION CLASSIFICATIONS

- A. Earth Excavation or "Excavation" consists of removing materials encountered to the subgrade elevations indicated and subsequent reuse or disposal of the materials removed. All excavation is classified as earth excavation unless it otherwise meets the classifications provided below for unauthorized excavation, additional excavation, or rock excavation.
- B. Rock Excavation:
 - 1. Rock excavation in trenches and footing excavations includes removal and disposal of materials and obstructions encountered which cannot be excavated with a 1.0 cubic yard (heaped) capacity, 42-inch-wide bucket on medium-size track-mounted hydraulic excavator equivalent to Caterpillar Model 215, rated at not less than 90 HP flywheel power and 30,000 lb. drawbar pull. Trenches and footing excavations in excess of 10-feet in width are classified as open excavation.
 - 2. Rock excavation in open excavations includes removal and disposal of materials and obstructions encountered which cannot be dislodged and excavated with modern track-mounted heavy-duty hydraulic excavating equipment without drilling or ripping. Rock excavation equipment is defined as Caterpillar Model No. 973 or No. 977K, or equivalent track-mounted loader, rated at not less than 170 HP flywheel power and developing 40,000-lb. breakout force (measured in accordance with SAE J732C).
 - 3. Determination of rock excavation classification will be made by the Engineer. Typical materials classified as rock are boulders 3.0 cubic yards or more in volume, solid rock, rock in ledges, and rock-hard cementitious aggregate deposits. Intermittent drilling or ripping performed to increase production and not necessary to permit excavation of material encountered will be classified as earth excavation. Do not perform rock excavation work until material to be excavated has been cross-sectioned and classified by the Engineer. Visual observation of the completed excavation may be made by the Engineer to modify the excavation classifications. Removal of rock excavation prior to classification by the Engineer shall be considered as earth excavation unless accepted by the Engineer in writing. Such excavation will be paid on the basis of contract unit rates for this classification.
 - 4. Rock payment lines (if applicable) are limited to the following:
 - a. Two feet outside of concrete work for which forms are required.
 - b. In footing excavations, one foot below bottom-of-footing elevation.
 - c. One foot below bottom-of-slab elevation.
 - d. One foot outside of the vertical walls of utility structures.
 - e. In pipe trenches, depth limits shall be 6 inches below the bottom of the pipe:

Depth from Ground Surface to Invert of Pipe	Pay Width (Pipe I.D.)	
	0 – 24"	Over 24"
0 to 12'	5'-0"	Pipe I.D. +3'-0"
12' to 20'	7'-0"	Pipe I.D. +7'-0"
Over 20'	9'-0"	Pipe I.D. +7'-0"

- f. Rock sloping across the width of trench shall have the top of rock established at the rock elevation over the centerline of the pipe.
 - g. For all other site improvements not listed above, including but not limited to landscape plantings, and roadways, the payment line for rock removal shall be the subgrade for installation of the earthen components of the particular site improvement.
- C. Unauthorized Excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of the Owner's Engineer. Unauthorized excavation, as well as remedial work required by the Owner's Engineer, shall be at the Contractor's expense.
- 1. Under footings, foundations, concrete slabs, retaining walls or other structures, fill unauthorized excavations to the proper elevations with Structural Fill as defined herein. Elsewhere, backfill and compact unauthorized excavations as specified for excavations of the same class, unless otherwise required.
- D. Additional Excavation:
- 1. When excavation has reached required subgrade elevations, notify the Owner's Engineer, who will observe subgrade conditions.
 - 2. If unsuitable foundation soils are encountered at the required subgrade elevations, carry excavations deeper and to the lateral extent as required by the Owner's Engineer. Replace excavated material with suitable backfill as specified herein.
 - 3. Removal of unsuitable foundation soils and its replacement as specified is included in the base Scope of Work and shall be included in the lump sum price. Contractor shall promptly notify the Owner and the Engineer if unsuitable foundation soil quantities represent, in the Contractor's opinion, a differing subsurface or physical condition. Any corresponding adjustment to the Contract Price and/or Contract Times shall be made in accordance with the Contract Documents.

1.9 EXCAVATION:

- A. Perform all excavations of materials encountered in a manner as required to allow for placing of temporary earth support, dewatering, forms, installation of pipe and other work, and to permit access for the purpose of observing the work. Excavations shall be wide enough to give suitable space for the required work. Bottoms of trenches and excavations shall be protected from frost and shall be firm, dry and in an acceptable condition to receive the work. Work shall not be placed on frozen surfaces nor shall work be placed on wet or unstable surfaces.
- B. All excavations made in open cut will be controlled by the conditions existing at that location. In no case shall earth be excavated or disturbed by machinery so near to the finished subgrade for structures and utilities as to result in the disturbance of the earth below the subgrade. The final

excavation to subgrade should be accomplished with a smooth bladed bucket or by hand. Subgrades shall be observed by the Owner's Engineer prior to placement of overlying materials including fill, concrete forms, and rebar.

- C. The Contractor shall segregate and stockpile separately materials that are considered viable for on-site re-use by the Owner's Engineer from materials which are considered not viable for on-site re-use and require off-site disposal.
- D. Temporary excavation support shall be provided in accordance with Section 31 50 00, TEMPORARY SUPPORT OF EXCAVATION.
- E. Dewatering shall be provided in accordance with Section 31 23 19, DEWATERING.

1.10 PERMITS, CODES, AND SAFETY REQUIREMENTS:

- A. Comply with all rules, regulations, laws and ordinances of the municipality, the Commonwealth of Massachusetts, and other authorities having jurisdiction over the project site or work. All labor, materials, equipment and services necessary to make the work comply with these requirements shall be provided by the Contractor without additional cost to the Owner.
- B. Comply with the provisions of the Manual for Accident Prevention in Construction of the Associated General Contractors of America, Inc., and the requirements of the Occupational Safety and Health Administration, United States Department of Labor.
- C. The Contractor shall obtain and pay for all permits and licenses required to the complete work specified herein and shown on the Contract Drawings.
- D. The Contractor shall not close or obstruct any street, sidewalk, or passageway without written permission from authorities having jurisdiction unless otherwise indicated on the Contract Drawings. The Contractor shall conduct their operations as to minimize interference with the use of roads, driveways, or other facilities near enough to the work to be affected by the work.
- E. The Contractor shall notify "Dig Safe" at 1-888-DIG-SAFE prior to commencing any excavation work.
- F. The Contractor shall provide police details when working in roadways as required by local jurisdictional authorities. The Contractor shall pay for any and all details.

1.11 PROTECTION OF EXISTING CONDITIONS:

- A. All work shall be executed in such a manner as to prevent any damage to existing buildings, streets, curbs, paving, service utility lines, structures at the site and adjoining properties. Protect existing improvements from damage caused by settlement, lateral movements, undermining, washout and other hazards created by earthwork operations.
- B. Locate and mark underground utilities to remain in service before beginning the work. All costs associated with protecting, maintaining, relocating, supporting, locating, digging test pits, etc. for all utilities shall be included in the bid price. Protect and support all existing utilities to remain in service during operations. Do not interrupt existing utilities except when authorized in writing by authorities have jurisdiction unless otherwise indicated on the Contract Drawings.

- C. When an active utility line is exposed during construction its location and elevation shall be recorded on the Record Drawings by the Contractor and both the Owner's Engineer and the Utility Owner shall be notified in writing. Active utilities existing on the site shall be carefully protected from damage or relocated as required by the work.
- D. Inactive or abandoned utilities encountered during construction operations shall be removed or abandoned in place by completely filling with grout or Controlled Density Fill in a manner to prevent voids. The location of such utilities shall be recorded on the Record Drawings.
- E. Provide barricades, fences, lights, signs, and all other safety devices required to protect the public against injury.
- F. In case of any damage or injury caused in the performance of the work the Contractor shall, at their own expense make good such damage or injury to the satisfaction of, and without cost to, the Owner. Existing streets, sidewalks and curbs damaged during the project work shall be repaired or replaced to their condition prior to commencement of earthwork operations. The Contractor shall replace, at their own cost, existing benchmarks, observation wells, monuments, and other reference points, which are disturbed or destroyed.
- G. Acceptance of any of the Contractor's plans, design calculations and methods of construction shall not relieve the Contractor of the responsibility for the adequacy of the excavation lateral support system; preventing damage to existing or new structures, utilities and streets adjacent to excavations; the safety of persons working within excavated areas and the public at large; and excavation dewatering.

1.12 EXPLORATORY EXCAVATION (TEST PITS):

- A. The Contractor shall conduct excavations to explore subsurface conditions and confirm the dimension and location of existing structure foundations indicated on Contract Drawings. Extend excavations a sufficient distance from structures for inspections.
 - 1. Excavations shall expose but not undermine existing foundations.
 - 2. Notify the Owner's Engineer when excavations have reached existing foundations to observe existing conditions.
- B. It shall be the responsibility of the Contractor at its expense to use satisfactory means and methods to protect and maintain the existing structures.

1.13 DRAINAGE:

- A. The Contractor shall provide, at its own expense, adequate drainage facilities to complete all work items in an acceptable manner. Drainage shall be done in a manner so that runoff will not adversely affect construction procedures or cause excessive disturbance of underlying natural ground or abutting properties.

1.14 FROST PROTECTION AND WET WEATHER:

- A. The Contractor shall, at its own expense, keep earthwork operations clear and free of accumulations of snow and ice as required to carry out the work.

- B. The Contractor shall protect the subgrade beneath new structures, utilities and areas of grade increases from frost penetration when freezing temperatures are expected.
- C. Silty soils are highly susceptible to softening and disturbance by construction activity during wet or freezing weather. Subgrade protection is the responsibility of the contractor and special precautions and protective measures appropriate for the weather conditions during construction shall be used during earthwork and foundation construction to preserve the integrity of subgrades. Disturbed subgrades shall be repaired at the sole expense of the Contractor.

PART 2 - PRODUCTS

2.1 EXISTING ON-SITE SOILS

- A. Existing available soil materials derived from required excavations may be reused as Common Fill provided the on-site materials meet the specified material requirements.

2.2 RECYCLED ASPHALT, CONCRETE, AND BRICK

- A. Use of processed and recycled demolition materials including, but not limited to, asphalt, brick and concrete, is not allowed.

2.3 SOIL MATERIALS

- A. Common Fill: Common Fill shall be well-graded, natural inorganic soil containing no stone greater than 6 inches maximum dimension and less than approximately 20 percent fines. The materials shall be free of trash, ice, snow, tree stumps, roots and other organic and deleterious materials. It shall be free of plastic clays, of all materials subject to decay or other materials that will corrode piping or metals. Common Fill shall have a maximum dry density of not less than 110 pounds per cubic foot. It shall be of such a nature and character that it can be compacted to the specified densities. Topsoil shall not be considered Common Fill.
- B. Gravel Borrow: Gravel Borrow shall satisfy the requirements listed in MassDOT Specification Section M1.03.0, Type b.
- C. Dense Graded Crushed Stone: Dense Graded Crushed Stone shall satisfy the requirements listed in MassDOT Specification Section M2.01.7.
- D. Structural Fill: Structural Fill shall satisfy the requirements of Gravel Borrow or Dense Graded Crushed Stone, above.
- E. Crushed Stone: Crushed Stone shall satisfy the requirements listed in MassDOT Specification Section M2.01.4 (3/4-inch crushed stone) unless otherwise required. Crushed Stone separated from the surrounding soil with Filter Fabric as specified herein may be used as Structural Fill where approved by the Owner's Engineer.
- F. Sand: Sand shall satisfy the requirements listed in MassDOT Specification Section M1.04.
- G. Controlled Density Fill (CDF) Type 2E: CDF Type 2E shall consist of a cementitious, excavatable mixture of aggregate, Portland Cement, air entraining admixtures and water meeting the requirements in MassDOT Specification Section M4.08.0 for Type 2E. Controlled density fill

shall be used as trench backfill material around structures (not including manholes and catch basins) where specified or as directed or approved by the Owner's Engineer.

- H. Controlled Density Fill (CDF) Type 1: CDF Type 1 shall consist of a cementitious mixture of aggregate, Portland Cement, air entraining admixtures and water meeting the requirements in MassDOT Specification Section M4.08.0 for Type 1. CDF Type 1 shall be used to fill abandoned utilities.

2.4 FILTER FABRIC

- A. Filter fabric used to complete the work of this Section shall be composed of a non-woven matrix of polypropylene or polyethylene filaments or yarns. The fabric shall be inert to organic chemicals commonly encountered in the soil and shall possess the properties of Tencate Mirafi 180N as manufactured by Tencate Geosynthetics.

PART 3 - EXECUTION

3.1 GENERAL

- A. The Contract Drawings indicate the proposed finish alignments, elevations, and grades of the work. Establish the line and grade in close conformity with the Contract Drawings. The Owner's Engineer, however, may make minor adjustments in the field as necessary due to conditions encountered.
- B. The Contractor is responsible for establishing construction phasing, means, and methods and interim grading and temporary conditions required to attain the finish product required by the Contract Documents. The Contractor is responsible for all construction, protection, movement, and maintenance of stockpiles. Establish and maintain suitable benchmarks and grade control to accurately perform the work.
- C. The Contractor shall maintain the surfaces of fill and backfill areas in good condition so as to present a smooth surface at all times level with adjacent surfaces. Any subsequent settling over backfilled areas shall be repaired by the Contractor immediately, and such maintenance shall be provided by the Contractor for the life of this Contract, at no additional expense to the Owner.
- D. The completed and approved subgrades upon which topsoil is to be placed, or pavements are to be installed, shall not be disturbed by traffic of other operations and shall be maintained in a satisfactory condition until the base and finished courses are placed. The storage or stockpiling of materials on finished subgrade will not be permitted.
- E. Uniformly shape the surfaces of all areas to be graded, to the lines and grades indicated on the Contract Drawings, and as directed, including excavated and filled sections, embankments and adjacent transition areas, and all areas disturbed as a result of the Contractor's operations. The finished surfaces shall be reasonably smooth, compacted and free from surface irregularities.
- F. The Contractor shall provide temporary erosion control to maintain all constructed lawns, and to protect all existing drains, catch basins, swales, from any debris or soil entering from excavation, backfill, or erosion. Contractor shall take whatever precautions necessary to accomplish temporary erosion control at no additional cost to the Owner.

3.2 EXCAVATION

- A. Cobbles and boulders within dense well-bonded soils or other competent, naturally deposited soils and/or any other features man-made, man-placed, or natural may be encountered during construction. The Contractor shall implement appropriate means and methods to advance the excavation through these materials and be prepared (equipment readily available) to remove these materials should they be encountered. No separate measurement or payment will be made for removal of these materials.
- B. All excavation shall be performed in the dry. Excavation and dewatering shall be accomplished by methods which preserve the undisturbed state of the subgrade soils.
- C. No excavation is permitted below the ZOI of any in-place footing or utility without providing adequate sheeting and bracing (designed by a Professional Engineer in Massachusetts and retained by the Contractor) to prevent movement of the in-place footing or utility.
- D. When excavations have reached the prescribed depths, the condition of the bottom of the trench, subgrade, or foundation bearing surface shall be observed by the Owner's Engineer prior to placement of overlying materials including concrete forms and rebar. When excavating to subgrade level for pavement and hardscaping areas has been completed, the subgrade surface shall be observed by the Owner's Engineer prior to placement of overlying materials.
- E. The Contractor shall follow a construction procedure, which permits visual identification of stable ground. Where groundwater and/or surface water are encountered, the size of the open excavation shall be limited to that which can be handled by the Contractor's chosen method of dewatering and which will allow visual observation of the bottom and backfilling with the excavation in the dry.
- F. The Contractor shall excavate unsuitable foundation soils to stable natural ground where encountered at proposed excavation subgrade, as specified herein. Unless specified elsewhere or otherwise required by the Owner's Engineer, areas where unsuitable foundation soils have been excavated to stable ground shall be backfilled with Structural Fill.
- G. No excavated material shall be deposited or stockpiled at any time to endanger portions of new or existing structures, either by direct pressure or indirectly by overloading areas contiguous to the operation. If there is not sufficient area available for stockpiling within the limits of the project, the Contractor will be required to furnish their own area for stockpiling.
- H. When excavation in areas in close proximity to existing buildings, roads, structures and utilities is required, it shall be the responsibility of the Contractor at their expense to use satisfactory means and methods to protect and maintain the stability of such roads, and structures.
- I. Temporary ditches shall be made as needed to drain off surface water to avoid damage to areas of cut or fill and disturbance or subgrades. Such ditches shall be maintained as required for efficient operations, at no additional cost to the Owner.
- J. The Contractor shall place a minimum of 12-inches of crushed stone wrapped in Filter Fabric to stabilize areas which may become disturbed as a result of rain, foot traffic, surface water runoff or groundwater seepage pressures, all at no additional cost to the Owner. The Contractor also has the option of drying materials in-place and compacting to specified densities.

- K. Provide shoring, sheeting, and/or bracing at excavations, as required, to assure complete safety against collapse of earth at the side of excavations. Provide shoring of public utility lines where exposed in the excavations in accordance with rules and regulations of the local authorities, as no additional cost to the Owner.

3.3 SUBGRADE PREPARATION AND OBSERVATION

- A. The subgrades for structure foundations and other site improvements shall be shaped to lines, grades, and cross-sections shown on the Contract Drawings.
- B. Operations for subgrade preparation shall include any required reshaping and moisture conditioning to obtain adequate compaction of loose granular materials or soils. Unsuitable foundation soils, as defined herein, shall be removed and replaced with acceptable backfill material. The resulting area, and all other low sections, holes, or depressions shall be brought to the required grade and the entire subgrade shaped to line, grade, and cross-section and thoroughly compacted according to the requirements of this Section. Any portion, which is not accessible to a roller, shall be thoroughly compacted by other mechanical or manual methods.
- C. All subgrades, included the excavations resulting from removal of unsuitable foundation soils, must be observed and accepted by the Owner's Engineer prior to placement of fill, backfill, or any structure over the subgrade. Observations may include proof-rolling with at least 4 passes of fully loaded, ten cubic yard dump truck over the subgrade or other acceptable compaction equipment subject to the approval of the Owner's Engineer. Where inaccessible, the Owner's Engineer may utilize compaction test results or other means to evaluate the suitability of the subgrade.

3.4 FILL AND BACKFILL MATERIALS

- A. Unless otherwise specified or required, the following materials shall be placed and compacted to the lines, grades, and cross-sections shown on the Contract Drawings and observed by the Owner's Engineer:
 - 1. Structural Fill: In areas requiring fill to raise grades or backfill to restore excavations to the required subgrade level, including excavations made to remove unsuitable foundation soils, Structural Fill shall be used within the ZOI beneath proposed foundations and slabs (including equipment pads) and within two feet of finished grade below paved surfaces where fill is required.
 - 2. Controlled Density Fill:
 - a. CDF Type 2E shall be used as trench backfill around structures (not including manholes and catch basins) where specified or as directed or approved by the Owner's Engineer, and within areas where the required degree of compaction cannot be achieved using conventional earth materials and compaction equipment.
 - b. CDF Type 1 shall be used to fill abandoned utilities.
 - 3. Common Fill: Common Fill may be used in areas not requiring Structural Fill or Controlled Density Fill. Common Fill shall not be used within the ZOI of structures or within two feet of finished graded below paved surfaces.

4. Crushed Stone: Below slabs-on-grade, a minimum thickness of 6-inches of Crushed Stone shall be placed and compacted.
5. Recycled Materials: Processed and recycled demolition materials such as crushed and screened boulders, concrete masonry building rubble, pavements, and other deleterious materials shall not be used as fill or backfill materials.

3.5 PLACEMENT OF FILL AND BACKFILL

- A. Backfill shall be placed and compacted to lines, grades, and cross-sections shown on the Contract Drawings and observed by the Owner's Engineer. Compaction testing shall be performed by the independent construction materials testing agency at the minimum testing frequency and the minimum compaction requirements specified herein.
- B. Maintain backfill material with a uniform moisture content, with no visible wet or dry streaking, between plus 3 percent and minus 3 percent of optimum moisture content. The final filled soil mass shall be as uniform as possible in lift thickness, moisture content, and effort required to compact soil mass. Backfill which is too wet for use shall be stockpiled, allowed to dry sufficiently, and reused by the Contractor at no additional cost to the Owner.
- C. Unless larger lifts are approved by the Owner's Engineer based on the mass and vibratory capabilities of specific compaction equipment and observed performance by the Owner's Engineer of test pad during construction, the fill thickness for each lift shall not exceed 10-inches in loose thickness.
- D. The vertical and lateral limits of Structural Fill below proposed footings and slabs-on-grade (the "zone of influence") shall be defined by a horizontal plane extending away from the outside bottom edge of the footings for two feet, then by a plane that slopes down and away from the foundation at a maximum 1H:1V slope to the subgrade shown on drawings. Structural Fill shall be placed within the zone described above in maximum 10-inch-thick lifts measured prior to compaction.
- E. All fills shall be placed in horizontal layers. Fill shall not be placed following the natural contours of the ground. Fill shall be placed starting in the lowest areas working up to finish grades in horizontal layers in the manner specified herein. Each layer of fill shall be benched into the existing slope in order to avoid the formation of a shear plane.

3.6 BACKFILLING UTILITY TRENCHES

- A. After the utility pipe installation has been inspected and approved, trenches shall be backfilled as soon as practicable with specified material.
- B. Backfill material for pipe bedding shall be deposited in the trench, uniformly on both sides of the pipe, for the entire width of the trench to the springline of the pipe. The backfill material shall be placed by hand shovels, in layers not more than 6-inches thick in loose depth, and each layer shall be thoroughly and evenly compacted by tamping on each side of the pipe to provide uniform support around the pipe, free from voids.
- C. The balance of backfill shall be spread in layers not exceeding 9-inches in loose depth. Each layer shall be thoroughly compacted by mechanical methods and shall contain no rock, stones or boulders larger than 4-inches in their greatest dimension.

- D. All trench backfilling shall be done with special care and must be carefully placed so as not to disturb the work at any time; if necessary, a timber grillage or other suitable method shall be used to break the fall of the material. Puddling of backfill with water will not be permitted. Backfill within areas to receive topsoil or pavement construction shall be made to grades required to establish the proper subgrade for the placement of topsoil or pavement base courses.
- E. In backfilling trenches, each layer of backfill material shall be moistened and compacted to a density as specified herein.
- F. Any trenches or excavations improperly backfilled or where settlement occurs shall be reopened, to the depth required for proper compaction, then refilled and compacted with the surface restored to the required grade and condition, at no additional expense to the Owner.

3.7 BACKFILLING AGAINST STRUCTURES

- A. Backfilling against masonry or concrete shall not be done until permitted by the Owner's Engineer. The Contractor shall not place backfill against or on structures until they have attained sufficient strength to support the loads (including construction loads) to which they will be subjected, without distortion, cracking or other damage.
- B. Prior to placing backfill, the areas shall be cleaned of all excess construction material and debris and the bottom of excavations shall be in a thoroughly compacted condition.
- C. Symmetrical backfill loading shall be maintained. Special care shall be taken to prevent any wedging action or eccentric loading upon or against the structures. During backfilling operations, care shall be exercised that the equipment used will not overload the structures in passing over and compacting these fills. Backfill shall be placed in 10 inches in loose depth and each layer of backfill shall be compacted thoroughly and evenly using approved types of mechanical equipment. Each pass of the equipment shall cover the entire area of each layer of backfill.
- D. In compacting and other operations, the Contractor shall conduct their operations in a manner to prevent damage to structures due to passage of heavy equipment over, or adjacent to, structures, and any damage thereto shall be made good by the Contractor at no additional expense to the Owner.

3.8 COMPACTION

- A. Compaction Requirements: The degree of compaction is expressed as a percentage of the maximum dry density of the material at optimum moisture content as determined by ASTM D 1557, Method C. The compaction requirements are as follows:

Area	ASTM D1557 Density Degree of Compaction
In the zone of influence below foundations, exterior slabs, and other structural features, including all Structural Fill	95%
Pavement, foundation and slab-on-grade base course, including all Dense Graded Crushed Stone and Gravel Borrow	95%
Trench backfill below pavements	95%
below landscaped areas	92%
below structures	95%
All other areas	92%

- B. Crushed Stone, where used, shall be compacted to a firm and unyielding condition as satisfactory to the Engineer.
- C. Moisture Control:
1. Fill that is too wet for proper compaction shall be disked, harrowed, or otherwise mixed and dried to a proper moisture content to allow compaction to the required density. If fill cannot be dried within 24 hours of placement, it shall be removed and replaced with drier fill.
 2. Fill that is too dry for proper compaction shall receive water uniformly applied over the surface of the loose layer. Sufficient water shall be added to allow compaction to the required density.
- D. Unfavorable Conditions:
1. In no case shall fill be placed over material that is frozen. In no case shall frozen soil or soil material containing frost, snow or ice be placed as backfill. No fill material shall be placed, spread or rolled during unfavorable weather conditions. When work is interrupted by heavy rains, fill operations shall not be resumed until the moisture content and the density of the previously placed fill are as specified.
 2. In freezing weather, a layer of fill shall not be left in an uncompacted state at the close of the day's operations. Prior to terminating work for the day, the final layer of compacted fill shall be rolled with a smooth wheeled roller to eliminate ridges.
- E. Compaction Control:
1. In-place density tests shall be made in accordance with ASTM D6938 as the work progresses, to determine the degree of compaction being attained by the Contractor. Any corrective work required as a result of such tests, such as additional compaction, or a decrease in the thickness of layers, shall be performed by the Contractor at no additional expense to the Owner. Additional in-place density testing shall be made at the Contractor's expense by the independent construction materials testing agency.

2. In-place density tests shall be performed at a minimum according to the following:
 - a. Under all Foundations – Each compacted lift, one for each independent foundation or one every 200 square feet of each lift (whichever results in more tests).
 - b. Slabs-on-Grade – Each compacted lift, one every 1,000 square feet of each lift.
 - c. Pavements – Each compacted lift and base course layer, one every 2,000 square feet of each lift.
 - d. Backfill of Trenches – One test for every 100 linear feet of each lift.
 - e. General Fill / Other Areas – One test every 5,000 square feet of each lift.

END OF SECTION

SECTION 31 05 19.13

GEOTEXTILE FABRICS

PART 1 - GENERAL

1.01 WORK INCLUDED:

This Section covers furnishing of all labor, materials, and equipment necessary to install specified geotextile fabrics in locations shown on the drawings and as required by the Engineer.

1.02 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01330 SUBMITTALS, SUBMIT THE FOLLOWING:

Shop drawings or working drawings and material specifications shall be submitted to the Engineer for review for each type of geotextile fabric furnished. General installation practices and installation schedule shall be included.

PART 2 - PRODUCTS

2.01 EROSION CONTROL FABRIC "A":

- A. Erosion control fabric "A" shall be composed of continuous-filament fibers bonded together to form a sheet. The fabric shall be an average of 20 mils thick and possess the pore-size distribution of Tencate Mirafi 600X Fabric.
- B. Erosion Control fabric "A" shall be Tencate Mirafi 600X as manufactured by Tencate Geosynthetics, Pendergrass, GA; or approved equal.

2.02 EROSION CONTROL FABRIC "B":

- A. Erosion Control Fabric "B" shall be of the best quality proven design and construction and shall be entirely suitable in every respect for the intended service.
- B. Erosion Control fabric "B" shall be Tencate Miramesh as manufactured by Tencate Geosynthetics, Pendergrass, GA; Enkamat Soil Erosion Matting as manufactured by Bonar, Asheville, N.C.; Tenax Radix Erosion Control Netting as manufactured by Tenax Corp., Baltimore, MD or approved equal.

2.03 SOIL REINFORCEMENT FABRIC:

- A. The soil reinforcement fabric shall be an integrally formed structure with aperture geometry and rib thickness sufficient to permit mechanical interlock with the surrounding particle media. The soil reinforcement fabric shall have flexural rigidity and high tensile modulus with continuity of tensile strength through all ribs and junctions of the structure.

The fabric shall be composed of polypropylene stabilized with carbon black to resist ultraviolet degradation and be resistant to biological and chemical degradation due to all naturally occurring organisms or reagents normally encountered in natural soil environments.

- B. The soil reinforcement fabric shall be a Tensar SS-2 (BX1200) Geogrid, by Contech Construction Products Inc., Marlboro, MA; Tencate Mirafi 500X fabric, by Tencate Geosynthetics, Pendergrass, GA; or approved equal.

2.04 SOIL REINFORCEMENT GRID:

- A. The soil reinforcement grid shall permit free passage of moisture, be of sufficient strength to prevent deformation and impairment of function when subjected to wheel loads and interact with overlying soil to stabilize the overburden on slopes as steep as three to one.
- B. Soil reinforcement grid shall be Tencate Mirafi Miragrid, by Tencate Geosynthetics; or approved equal.

2.05 FILTER/DRAINAGE FABRIC:

- A. The filter/drainage fabric shall be composed of continuous-filament fibers bonded together to form a sheet. The fabric shall be an average of 20 mils thick and possess the characteristics of Tencate Mirafi 140N.
- B. The filter/drainage fabric shall be Tencate Mirafi 140N as manufactured by Tencate Geosynthetics, Pendergrass, GA; Foss-65 by Foss Manufacturing Co., Hampton, NH; US 120NW, as manufactured by US Fabrics, Cincinnati, OH, or approved equal.

2.06 GEOTEXTILE LINER PROTECTOR:

- A. The geotextile liner protector shall be a non-woven, needle punched polyester or extruded polypropylene, not less than 110 mils thick.
- B. The geotextile liner protector shall be Tencate Mirafi 180 N, by Tencate Geosynthetics, Pendergrass, GA; or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. GENERAL:

Installation of geotextile fabrics shall be strictly in accordance with manufacturer's instructions and specific layout plans and details reviewed by the Engineer.

B. EROSION CONTROL FABRIC “A”:

Erosion control fabric “A” shall be installed on detention basin slopes and at drainage swale ends prior to placement of riprap and at other locations as shown on the drawings or as required by the Engineer. The fabric in place shall cover the entire riprap area. Each width of fabric shall be overlapped by the subsequent width a minimum of two feet. The Contractor shall follow the manufacturer's installation recommendations to ensure proper completion of the fabric installation, including top toe-in and bottom toe wrap.

C. EROSION CONTROL FABRIC “B”:

Erosion control fabric “B” shall be placed over the prepared surface in drainage swales and other locations as required by the Engineer. The fabric shall be unrolled, placed in the direction of water flow, overlapped, pinned down with wood stakes, and seeded. All installation work shall be in accordance with manufacturer's recommendations or as required by the Engineer.

D. SOIL REINFORCEMENT FABRIC:

The soil reinforcement fabric shall be installed on the prepared subgrade prior to placement of the gravel base and bituminous concrete pavement. The fabric in place shall be beneath the entire proposed paved area. Each width of fabric shall be overlapped by the subsequent width a minimum of two feet. The Contractor shall follow the manufacturer's installation recommendations.

E. SOIL REINFORCEMENT GRID:

The soil reinforcement grid shall be placed on the flexible membrane liner, securely fastened at the top of all slopes and interlocked to form a continuous grid below the supports, all in accordance with manufacturer's recommendations and specific project details. The reinforcement grid shall provide stability for the overlying soil drainage layer, while permitting free passage of moisture.

F. FILTER/DRAINAGE FABRIC:

1. The filter/drainage fabric shall be installed in the final graded trench bottom prior to placement of the crushed stone bedding and at other locations shown on the drawings or designated by the Engineer. The drainage fabric in place shall cover the entire trench bottom and trench sides as shown on the drawings. Each width of drainage fabric shall be overlapped in accordance with manufacturer's recommendations, but not less than 2 feet, to prevent intrusion of soil fines into the bedding.
2. On landfill projects, the filter/drainage fabric shall be installed over the drainage layer prior to loaming and seeding, per manufacturer's installation recommendations.

G. GEOTEXTILE LINER PROTECTOR:

The geotextile liner protector shall be installed on top of the gas-venting layer and shall be covered by the flexible membrane liner. The protector shall provide a smooth surface to support the liner and protect against liner damage due to projections. The installation shall be strictly in accordance with manufacturer's recommendations.

3.02 FINAL INSPECTION AND ACCEPTANCE:

- A. The Contractor shall, at its expense, have a manufacturer's representative inspect the work at completion of the installation. Any work found to be unsatisfactory shall be corrected at the Contractor's expense.
- B. The Engineer, at the Contractor's expense, reserves the right to have a manufacturer's representative inspect the installation process at any time during construction.

END OF SECTION

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SECTION 31 11 00

CLEARING AND GRUBBING

PART 1 - GENERAL

1.01 WORK INCLUDED:

- A. The Contractor shall do all required clearing and grubbing as indicated on the drawings or herein specified in the area required for construction operations on the Owner's land or in the Owner's permanent or temporary easements and shall remove all debris resulting therefrom.
- B. Unless otherwise noted, all areas to be cleared shall also be grubbed.
- C. The Contractor shall not clear and grub outside of the area required for construction operations.

1.02 RELATED WORK:

Any trees and shrubs specifically designated by the Owner not to be cut, removed, destroyed, or trimmed shall be saved from harm and injury in accordance with Section 01 57 19, ENVIRONMENTAL PROTECTION.

PART 2 - PRODUCTS: NOT APPLICABLE

PART 3 - EXECUTION

3.01 RIGHT TO WOOD AND LOGS:

The Owner shall have the right to cut and remove logs and other wood of value in advance of the Contractor's operations. All remaining logs and other wood to be removed in the course of clearing shall become the property of the Contractor.

3.02 CLEARING:

- A. Unless otherwise indicated, the Contractor shall cut or otherwise remove all trees, saplings, brush and vines, windfalls, logs and trees lying on the ground, dead trees and stubs more than 1-foot high above the ground surface (but not their stumps), trees which have been partially uprooted by natural or other causes (including their stumps), and other vegetable matter such as shags, sawdust, bark, refuse, and similar materials.
- B. The Contractor shall not remove mature trees (4-inches or greater DBH) in the Owner's temporary easements.
- C. Except where clearing is done by uprooting with machinery or where stumps are left longer to facilitate subsequent grubbing operations, trees, stumps, and stubs to be cleared

shall be cut as close to the ground as practicable but not more than 6-inches above the ground surface in the case of small trees, and 12-inches in the case of large trees. Saplings, brush and vines shall be cut close to the ground.

3.03 GRUBBING:

- A. Unless otherwise indicated, the Contractor shall completely remove all stumps and roots to a depth of 18-inches, or if the Contractor elects to grind the stumps, they shall be ground to a minimum depth of 6-inches.
- B. Any depression remaining from the removal of a stump and not filled in by backfilling shall be filled with gravel borrow and/or loam, whichever is appropriate to the proposed ground surface.

3.04 DISPOSAL:

All material collected in the course of the clearing and grubbing, which is not to remain, shall be disposed of in a satisfactory manner away from the site or as otherwise approved. Such disposal shall be carried on as promptly as possible and shall not be left until the final clean-up period.

END OF SECTION

SECTION 31 13 13

TREE PRUNING AND TREE AND STUMP REMOVALS

PART 1 - GENERAL

1.01 WORK INCLUDED:

- A. The work of this Section includes the following:
 - 1. Pruning - Class II, including the removal of all limbs necessary to execute the work required under this contract.
 - 2. Removal of trees and stumps.
- B. Refer to the Contract Drawings for general location of the proposed tree line along the site perimeter. In general, those trees forming the edge of the proposed tree line shown on the plans are to remain and be pruned in conformance with this Specification. Tree removals shall include the removal of individual trees that would impede the construction of proposed facilities.

1.02 QUALIFICATIONS OF CONTRACTOR:

- A. This work shall be limited to individuals, partnerships and corporations who are actively engaged in the field of Arboriculture, and who demonstrate competence, experience and financial capability to carry out the terms of this project. The Owner may require proof of these qualifications.
- B. All work shall be conducted by qualified and trained personnel under the direct supervision of a Massachusetts Certified Arborist (MCA) in the Contractor's employ.

1.03 PERSONNEL:

- A. The Contractor shall submit each employee's name and title prior to the commencement of work. The Contractor shall advise the Owner of any changes in personnel assigned to this Contract.
- B. The crew foreman shall have a minimum of five (5) years climbing/pruning experience. At least one (1) crew person shall be an MCA and shall be certified in CPR.
- C. Each trimmer shall be experienced and highly qualified with the necessary tree worker skills to successfully complete the work of this Section, including the ability and training to perform aerial rescue. Said skill shall also include worker safety and ability in compliance with current OSHA and ANSI Z-133.1 Standards.

1.04 SPECIAL REQUIREMENTS:

- A. Dutch Elm diseased wood shall be disposed of in accordance with provisions of General Laws, Chapter 87, Section 5, and Chapter 132, Sections 8 and 11 as amended; and in accordance with any additional local regulations. All wood shall be removed from the site and be properly disposed of in accordance with state and local regulations.
- B. No burning shall be permitted on the project site.
- C. Prior to commencing work, the Contractor shall submit a plan to the Owner for legal disposal of removed materials, in conformance with State and Federal regulations.

1.05 STANDARDS AND DEFINITIONS:

- A. All pruning work shall be performed in accordance with the following:
 - 1. The ANSI A300 'Standard Practices for Trees, Shrubs, and Other Wood Plant Materials' of the Secretariat: National Arborist Association, Post Office Box 1094, Amherst, New Hampshire 03031.
 - 2. American National Standards Institute (ANSI) Standard Z-133.1.
 - 3. The standards and practices of the International Society of Arborists.
 - 4. The standards and practices of the Massachusetts Arborist Association.
 - 5. The standards and practices of the American Association of Nurserymen.
- B. The term 'Owner' shall mean the Owner's designated representative charged with carrying out the requirements of this Project, Architect, Engineer, Planner, or Tree Warden as referenced herein, rendering approvals for the Owner.

1.06 EXAMINATION OF SITE AND DOCUMENTS:

- A. The Contractor shall be responsible for having a clear understanding of the existing site conditions and shall be responsible for fully carrying out the work of this Section, regardless of actual site conditions encountered.

1.07 ORDER OF WORK:

- A. Based on the site conference, the Contractor shall submit a schedule of work for the Owner's review and approval prior to beginning work. Unless otherwise authorized by the Owner, failure of the Contractor to comply with the approved removal

schedule shall be sufficient cause to give notice that the Contractor is in default of the contract.

1.08 PROTECTION OF THE VEGETATION TO BE PRESERVED:

- A. The Contractor shall protect all existing trees, shrubs, lawns and other site features designated to remain. The placement of protection devices, such as snow fence enclosures, shall, however, be at the Contractor's discretion.
- B. Damage no plant to remain by burning, pumping water, cutting of live roots or branches, or any other means. Neither vehicles nor equipment shall be parked within the dripline of trees to remain, or where ever damage may result to trees to be saved. Construction material shall not be stored beneath trees to be saved.
- C. The Contractor shall be liable for any damage to any trees, shrub, lawn or other site features to remain, and shall immediately report to the Owner. Damaged shrubs or lawns shall be restored or replaced to match existing to remain to the satisfaction of the Owner.
- D. The Contractor shall compensate the Owner for damages by installing replacement tree(s) of the size and species approved by the Owner and of sufficient quantity such that the sum of the Diameter at Breast Height (DBH) inches for replacement trees equals the total DBH inches of the damaged tree(s). Damaged shrubs shall be replaced with shrubs(s) of the same size, species, and quantity, unless determined otherwise by the Owner.

1.09 USE AND CARE OF THE SITE:

- A. The Contractor shall leave the work site at the end of each working period in a condition satisfactory to the Owner.
- B. Pavements shall be swept and lawns or other surfaces raked and/or otherwise cleaned of all material related to the work operation. Degree of clean-up required will be described by the Owner and will be based upon the character of the work area.
- C. All trimmings or any other form of debris (except diseased materials or trimmings from Elms) shall be collected and chipped. The Contractor shall remove all materials and shall dispose of such materials off site in a legal manner.
- D. No vehicles are to be stored on site. The Contractor shall be fully and solely responsible for any damage to equipment or vehicles left at the site of the work. All necessary permits shall be obtained by the Contractor.

PART 2 - PRODUCTS

2.01 EQUIPMENT:

- A. Equipment necessary for this Contract shall be properly maintained and in good operating condition to the City's satisfaction. The Contractor shall promptly remove and replace any equipment which the Owner deems to be in unsatisfactory condition or otherwise unsuitable.
- B. Cutting tools shall be kept well sharpened to provide clean smooth cuts. Any tools utilized on any tree suspected to have cankers or other fungal, bacterial or viral diseases shall be sterilized or not used on any other specimen.
- C. A disc chipper shall be used which will process material up to twelve (12) inches in diameter.

PART 3 - EXECUTION

3.01 PRUNING:

- A. Under this Section, the Contractor shall furnish all labor, materials, equipment and transportation required to complete all aspects of the work in accordance with all local, state and federal regulations in force at the same time of this Contract and in accordance with tree pruning as specified herein.
- B. The work of this Section consists of all pruning work and related items as specified herein and includes, but is not limited to:

- 1. Pruning - Class II throughout the designated areas and limb removal required to allow for the proper installation of all new construction.

Class II pruning is defined as medium pruning and shall consist of the removal of dead, dying, diseased, interfering, objectionable and weak branches on the main trunks as well as those within the leaf area. An occasional branch one (1) inch or less in diameter may remain within the main leaf area where it is not practical to remove it.

3.02 DESCRIPTION OF PRUNING WORK:

- A. Pruning and trimming are generally described as the removal and disposal of limbs, branches and stubs which are either dead, potentially detrimental to the health of the tree or dangerous to pedestrians, visually deficient, interfering or otherwise objectionable as determined by the Owner.
- B. The limits of all trees to be pruned have been identified on the plans or referenced elsewhere in this specification section. In general, those trees forming the edge of the

proposed tree line shown on the plans are to remain and be pruned in conformance with this Specification.

- C. Vehicle access shall be controlled and approved by the Owner.
- D. If the Contractor discovers tree(s) which have not been marked for pruning, but whose condition is such that removal is warranted, whether due to death, disease, decay, or structural weakness, such tree(s) shall not be pruned and the Contractor shall immediately report these findings in writing to the Owner and await the Owner's direction before proceeding with work on the particular tree(s) in question.
- E. All pruning shall be performed in a manner that maintains the natural aesthetic characteristics of the species and variety of trees. No topping or dehorning of trees or stubbing back of branches shall be permitted. All cuts shall be made to a lateral branch that is a minimum of one third (1/3) the size of the branch being removed, unless otherwise instructed by the Owner.
- F. The use of climbing spurs or spiked shoes shall not be permitted and their use will result in the immediate cancellation of the contract.
- G. All cuts shall be made sufficiently close to the parent stem so that wound closure can be readily started under normal conditions. Cuts shall, however, never be made through the branch collar. Slab cuts and rip cuts will result in cancellation of the contract.
- H. All limbs over two (2) inches in diameter to be removed shall be precut to prevent splitting. Any branches that by falling would injure existing trees to remain or other objects shall be lowered to the ground by proper ropes.
- I. On trees known to be diseased and where there is known to be danger of transmitting the disease on tools, tools shall be disinfected with alcohol or bleach after each cut between trees.
- J. Lateral branches as well as occasional branch suckers ("water sprouts") may be retained. Complete removal of secondary laterals and branch suckers resulting in the stripping of major limbs, ("lion tailing") will not be permitted.
- K. Tree paint to seal pruning cuts shall not be used.
- L. All branches and limbs shall be manually lowered to the ground via rope and pulley. This practice must be consistent with the National Arborist Association Standards for Pruning. All grade-level artifacts and landscaping must be protected from damage.

3.03 REMOVALS:

- A. The Contractor shall furnish all labor, materials, equipment and transportation required to complete all aspects of the removals work in accordance with all local, state, and federal regulations in force at the time of this contract and in accordance with tree and stump removals as specified herein.

3.04 DESCRIPTION OF REMOVAL WORK:

- A. Removal is generally described as the removal of groups and individual trees and shrubs which interfere with the growth of more desirable types of trees; the clearing away of lesser growth that may obscure outstanding trees; and thinning out to provide space for healthy growth by the elimination of thinner, weaker trees.
- B. The Contractor shall adhere to the specifications and provide suitable facilities for inspecting the work. Failure of the Owner to immediately reject unsatisfactory work or to notify the Contractor of deviations from the specification shall not relieve the Contractor of responsibility to correct or remedy unsatisfactory work.
- C. The Contractor shall only work on trees designated by the Owner. No compensation will be made for work performed on any other tree or trees.
- D. Trees designated to be removed shall be taken down and all leaves, branches and trunks of trees properly disposed of by chipping and removal from the premises.
- E. Fell trees in a manner that allows all site features and those trees to be saved undamaged.
- F. Removal of all the parts of each tree shall be completed on the same day that the tree is cut.
- G. Stumps shall be ground to eighteen (18) inches below grade by grinding or other means acceptable to the Owner. The void from the stump removal operations shall be filled with ordinary borrow soil to within six (6) inches of finished grade. The top six (6) inches shall be filled with screened loam, moderately tamped to prevent future settling. In grass areas the disturbed area shall be sown with grass seed of a mix appropriate to the location, as required by the Owner.
- H. Excavation or grading within the branch spread of trees to be saved shall be performed as required by the Owner. Removal of pavement such as bituminous concrete in these zones shall be by hand tools and/or air spade to ensure root health for trees to remain.
- I. All equipment to be used and all work to be performed must be in full compliance with all standards as promulgated by OSHA at the time of bidding, including but not limited to those regulations concerning noise levels, protective devices and operator

safety.

- J. The Contractor shall be solely responsible for pedestrian and vehicular safety and control within the work site and shall protect the public and its property from injury or damage that could be caused by the progress of the work. To this end the Contractor shall provide, erect, and maintain protective devices acceptable to the Owner, including but not limited to barricades, lights and warning signs.
- K. Any practice employed by the Contractor that is obviously hazardous as determined by the Owner shall be immediately discontinued by the Contractor upon receipt of either written or oral notice from the Owner to discontinue such practice.

END OF SECTION

SECTION 31 23 19
DEWATERING

PART 1 - GENERAL

1.01 WORK INCLUDED:

This section specifies designing, furnishing, installing, maintaining, operating and removing temporary dewatering systems as required to lower and control water levels and hydrostatic pressures during construction; disposing of pumped water; constructing, maintaining, observing and, except where indicated or required to remain in place, removing of equipment and instrumentation for control of the system.

1.02 RELATED WORK:

- A. Section 00 31 43, PERMITS
- B. Section 01 57 19, ENVIRONMENTAL PROTECTION
- C. Section 31 00 00, EARTHWORK
- D. Section 31 50 00, SUPPORT OF EXCAVATION

1.03 SYSTEM DESCRIPTION:

- A. Dewatering includes lowering the water table and intercepting seepage which would otherwise emerge from the slopes or bottom of the excavation; increasing the stability of excavated slopes; preventing loss of material from beneath the slopes or bottom of the excavation; reducing lateral loads on sheeting and bracing; improving the excavation and hauling characteristics of sandy soil; preventing rupture or heaving of the bottom of any excavation; and disposing of pumped water.
- B. Normal dewatering is defined as using conventional pumps installed in open excavations, ditches, or sumps. Special dewatering is defined as using single or two stage wellpoints, deep wells, or eductor and ejector systems installed in drilled holes or jetted in place.

1.04 QUALITY ASSURANCE:

- A. The Contractor is responsible for the adequacy of the dewatering systems. It shall retain the services of a Professional Engineer registered in the state where the project is located, experienced in dewatering systems, to independently evaluate the boring logs and any other soils information available to determine those areas that will require special dewatering techniques and to design the required system. The Contractor's Professional Engineer shall provide sufficient on-site inspection and supervision to assure that the dewatering is carried out in accordance with its design.
- B. The dewatering systems shall be capable of effectively reducing the hydrostatic pressure and lowering the groundwater levels to a minimum of 2 feet below excavation bottom, unless otherwise required by the Engineer, so that all excavation bottoms are firm and dry.

- C. The dewatering system shall be capable of maintaining a dry and stable subgrade until the structures, pipes and appurtenances to be built therein have been completed to the extent that they will not be floated or otherwise damaged.
 - D. The dewatering system and excavation support (see Section 31 50 00) shall be designed so that lowering of the groundwater level within the work area does not adversely affect structures, utilities or wells outside of the work area.
 - E. Where special dewatering is used, the Contractor shall obtain at its expense the services of a registered professional engineer to investigate, design and monitor the dewatering system. The Contractor shall also furnish materials and install at least two observation wells at each excavation area. The location of the wells shall be determined in the field by the Contractor's engineer.
- 1.05 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF GENERAL SPECIFICATIONS, SUBMIT THE FOLLOWING:
- A. At least two weeks prior to installing its dewatering system, Contractor shall submit the attached Certificate of Design completed and signed by Contractor, identifying the engineer responsible for design of the dewatering system. It shall also submit a schedule showing the timing of installation and operation of the dewatering system.
 - B. The Contractor shall submit to the Engineer for record purposes only, the following items bearing the Contractor's Engineer's stamp and signature, and identifying the codes and specifications followed in the design.
 - 1. Plans and description of the dewatering system, including the number, location and depth of wells, wellpoints or sumps; designs of filters to prevent pumping of fine soil; method and location for filtering and disposal of pumped water; and flow capacity of proposed system.
 - 2. Locations of observation wells.
 - C. The Contractor shall submit records of pump operation and groundwater elevations as required by the Owner's Engineer.

PART 2 - PRODUCTS: NOT APPLICABLE

PART 3 - EXECUTION

3.01 DEWATERING OPERATIONS:

- A. All water pumped or drained from the work shall be disposed of in a manner which will not result in undue interference with other work or damage to adjacent properties, pavements and other surfaces, buildings, structures and utilities. Suitable temporary pipes, flumes or channels shall be provided for water that may flow along or across the site of the work. All disposal of pumped water shall conform to the provisions of Section 01 57 19 ENVIRONMENTAL PROTECTION and Section 00 31 43 PERMITS.
- B. Dewatering facilities shall be located where they will not interfere with utilities and construction work to be done by others.
- C. Dewatering procedures to be used shall be as described below:

1. Crushed stone shall encapsulate the suction end of the pump to aid in minimizing the amount of silt discharged.
 2. For dewatering operations with relatively minor flows, pump discharges shall be directed into straw bale sedimentation traps lined with filter fabric. Water is to be filtered through the straw bales and filter fabric prior to being allowed to seep out into its natural water course.
 3. For dewatering operations with larger flows, pump discharges shall be into a steel dewatering basin. Steel baffle plates shall be used to slow water velocities to increase the contact time and allow adequate settlement of sediment prior to discharge into waterways.
 4. Where indicated on the contract drawings or in conditions of excess silt suspended in the discharge water, silt control bags are to be utilized in catch basins.
- D. The Contractor shall be responsible for repair of any damage caused by its dewatering operations, at no cost to the Owner.

3.02 SPECIAL DEWATERING:

- A. If conventional dewatering methods are inadequate to ensure dry and stable conditions for structural foundations, the Contractor shall be required to use special dewatering as necessary.
- B. Special dewatering techniques may consist of one or two stage wellpoint systems, deep wells, or eductor and ejector type systems. The Contractor shall utilize a system which provides proper construction conditions and prevents settlement at time of installation and upon backfilling.
- C. In areas requiring special dewatering, the Contractor shall lower the groundwater level to a minimum of 2 feet below the bottom of the final excavation grade prior to any installation and maintain that groundwater level until the excavation has been backfilled. The Contractor's engineer shall monitor the groundwater levels to ensure conformance with the requirements of these specifications. Construction will not be allowed until the Owner's Engineer is satisfied that the above provisions are met.

3.03 NOISE LEVEL REQUIREMENTS:

- A. All primary dewatering equipment shall be electrically operated and shall run on commercial power. Standby equipment shall be independent of commercial power and shall provide dewatering upon primary pump or power failure.
- B. All equipment utilized by the Contractor shall conform to the Department of Environmental Protection Division of Air Quality Control regulations governed by the following policy:

"A source of sound will be considered to be violating the Department's noise regulation (310 CMR 7.10) if the source:

1. Increases the broadband sound level by more than 10 dB(A) above ambient, or
2. Produces a "pure tone" condition - when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more.

These criteria are measured both at the property line and at the nearest inhabited residence. Ambient is defined as the background A-weighted sound level that is exceeded 90% of the time measured during equipment operating hours. The ambient may also be established by other means with the consent of the Department."

The Contractor shall construct sound enclosures or utilize other noise reduction techniques if the equipment does not meet the noise level requirements.

END OF SECTION

(Certificate of Design follows this page)

CERTIFICATE OF DESIGN

Re: Contract Between:

OWNER:

(Name)

and

CONTRACTOR:

(Name)

on

CONTRACT:

(Number)

Date:

Title:

Contractor hereby certifies that

:

(Engineer)

1. Is licensed or registered to perform professional engineering work in the state of
;
(Location of Project)
2. Is qualified to design the
(Item)
specified in Section of subject contract;
3. Has designed before;
(Item)
4. Has prepared the design in full compliance with the applications and requirements of
Section of subject contract including all applicable laws, regulations, rules, and
codes; and
5. The work has been signed and sealed pursuant to applicable state law.

FOR:

(Contractor)

BY:

(Signature)

(Name and Title)

Dated:

SECTION 31 25 00

EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.01 SCOPE OF WORK:

- A. Furnish all labor, materials, tools and equipment, and perform all operations necessary for erosion and sedimentation control work indicated on contract drawings and as specified herein.

1.02 RELATED WORK:

- A. Section 01 14 19.16, DUST CONTROL
- B. Section 01 57 19, ENVIRONMENTAL PROTECTION
- C. Section 31 05 19.13, GEOTEXTILE FABRICS

1.03 PROJECT CONDITIONS:

- A. Earthmoving activities in the project area shall be conducted in such a manner as to prevent accelerated erosion and the resulting sedimentation.
- B. The Contractor shall implement and maintain erosion and sedimentation control measures as shown on the contract drawings or as required by the Owner or Engineer from the start of construction until provisional acceptance of seeded areas, to effectively prevent accelerated erosion and sedimentation.

1.04 SUBMITTALS IN ACCORDANCE WITH SECTION 01 33 23, SUBMITTALS:

- A. The Contractor shall submit to the Engineer certification that the materials used for silt fence and straw wattle construction meet the specifications.

1.05 GENERAL METHODOLOGY:

- A. Erosion and sedimentation control methods shall consider all factors which contribute to erosion and sedimentation including, but not limited to, the following:
 - 1. Topographic features of the Project area.
 - 2. Types, depth, slope and areal extent of the soils.

3. Proposed alteration of the area.
4. Amount of run-off from the Project area and the upgradient watershed areas.
5. Staging of earthmoving activities.
6. Temporary control measures and facilities for use during earthmoving.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Straw wattle shall consist of 99.9% weed-free wheat, oat, barley, or rice straw, compacted. Diameter may vary +/- 13 percent. Wattle netting shall be non-woven photodegradable HDPE with a 1 year UV inhibitor.
- B. Silt Fence shall be a woven polypropylene and/or polyester material, which meets or exceeds the minimum average roll values requirements tabulated below:

Fabric Property	Test Method	Fabric Requirement
Tensile strength, lbs	ASTM D-4632 Grab	100 minimum
Elongation at 50% minimum tensile strength	ASTM D-4632 Grab	50% maximum
Permittivity, sec ⁻¹	ASTM D-4491	0.1 minimum
Apparent opening size, mm	ASTM D-4751	0.84 maximum
Ultraviolet degradation at 500 hours	ASTM D-4355	minimum 70% strength retained

- C. Mulch, if used to protect the hydroseed from erosion, shall consist of cured straw free from primary noxious weed seeds, twigs, debris and rough or woody materials. Mulch shall be free from rot or mold and shall be acceptable to the Engineer or Owner. Alternately, mulch shall be specially processed cellulose homogeneous fiber containing no growth or

germination-inhibiting factors. Processed cellulose fiber shall be manufactured in such a manner that after addition and agitation in slurry tanks with water, the fibers in the material become uniformly suspended to form a slurry when sprayed on the ground. The material shall allow homogeneous absorption and percolation of moisture. The manufacturer shall show the air-dry weight content on each package of the cellulose fiber. Mulch shall be utilized on all newly graded subgrade and topsoil areas that cannot be seeded within five (5) days.

PART 3 - EXECUTION

3.01 CONSTRUCTION SEQUENCE:

- A. Construction of erosion control measures as depicted on drawings will be completed prior to any site work.
- B. Sediment barriers shall be used at locations shown on the drawings. Sediment barriers are temporary berms, diversions, or other barriers that are constructed to retain sediment on-site by retarding and filtering stormwater runoff.
- C. All temporary erosion control measures will be maintained throughout the course of site construction activities until provisional acceptance of the site vegetation by the Engineer or Owner, at which time the Contractor shall remove all remaining temporary erosion control structures, and properly dispose of accumulated sediment on-site in areas approved by the Owner.
- D. The Engineer or Owner may order additional erosion and sediment controls be installed. The Contractor shall comply with Engineer or Owner's request and immediately install the required controls.
- E. The Contractor shall inspect all erosion control measures after any storm event to ensure they are in proper working order.

3.02 CONSTRUCTION METHODS:

- A. Silt fences and/or straw wattles shall be installed at the site downgradient of work areas as required by Owner or Engineer in the field. The silt fence shall be installed in accordance with manufacturer's instructions. Straw wattles shall be placed at locations shown on the contract drawings or approved by the Engineer. The base of all straw wattles and silt fencing shall be embedded to the depths shown on the contract drawings.
- B. Straw mulch, if used, shall be applied at a rate of 100-lbs/1000 ft².
- C. On slopes, the Contractor shall provide protection against washouts by an approved method. Any washout, which occurs either in the Contractor's

work area or in areas topographically below its work, shall be regraded and reseeded at the Contractor's expense until an accepted vegetative stand is established.

END OF SECTION

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Erosion and Sedimentation Control.docx

SECTION 31 37 00

RIPRAP

PART 1 - GENERAL

1.01 WORK INCLUDED:

- A. This Section covers riprap for slope protection, drainage swales and pipe ends, complete.
- B. Grading and compaction of earth slopes and other slope preparation for the riprap are included under other sections of the specification.

1.02 RELATED WORK:

- A. Section 31 00 00, EARTHWORK.
- B. Section 31 05 19.13, GEOTEXTILE FABRICS.

1.03 REFERENCES:

- A. The following standard forms a part of these specifications and indicates minimum standards required:

Massachusetts Department of Transportation (MassDOT) Standard Specifications for Highways and Bridges.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. SLOPE PROTECTION:

Stone for slope protection shall be angular and shall be in accordance with MassDOT Specification Section M2.02.2, Dumped Riprap.

B. PIPE ENDS:

Stone for pipe ends shall be angular and shall be in accordance with MassDOT Specification Section M2.02.3, Stone for Pipe Ends.

C. DRAINAGE SWALES:

Stone for drainage swale ends shall conform to MassDOT Specification Section M2.02.3, and shall be not weigh less than 50 pounds or more than 125 pounds and least 75% of the volume shall consist of stones not less than 75 pounds each. The stones shall be so graded that when placed with larger stones, the entire mass will be compact.

D. GEOTEXTILE FABRIC:

Geotextile fabric shall be Erosion Control Fabric "A" as specified in Section 31 05 19.13, GEOTEXTILE FABRICS.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Geotextile fabric shall be installed where shown on the drawings, prior to placing the riprap.
- B. Riprap for slope protection and pipe ends shall be placed on the prepared slope or area in a manner which will produce a reasonably well-graded mass of stone with the minimum practicable percentage of voids and a maximum void of 12-inches.
- C. Riprap shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the underlying material. Placing of riprap in layers or by dumping into chutes or by other similar methods likely to cause segregation will not be permitted.
- D. Riprap stones shall be placed and distributed such that there will be no large accumulation of either the larger or smaller stones in any given area.
- E. It is the intent of these specifications to produce compact riprap protection in which all required sizes of stone are placed in the proper proportions. Hand placing or rearranging of individual stones by mechanical equipment shall be utilized to the extent necessary to secure the desired results.

END OF SECTION

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SECTION 31 50 00
SUPPORT OF EXCAVATION

PART 1 - GENERAL

1.01 WORK INCLUDED:

- A. This section covers wood and steel sheeting or soldier piles and lagging with internal bracing for support of excavations. The requirements of this section shall also apply, as appropriate, to any methods of excavation support and underpinning which the Contractor elects to use to complete the work.
- B. The Contractor shall furnish and place timber or steel sheeting or soldier piles and lagging of the kinds and dimensions required, complying with these specifications, where required by regulation, indicated on the drawings or required by the Engineer.
- C. Vibration monitoring shall be provided during installation and extraction of sheeting whenever the braced excavation is adjacent to existing structures, in critical areas as noted in the contract documents, or as requested by the Engineer.
- D. Routine monitoring of the in-place excavation support system shall be provided.

1.02 RELATED WORK:

- A. Section 31 00 00, EARTHWORK
- B. Section 31 23 19, DEWATERING

1.03 QUALITY ASSURANCE:

- A. This project is subject to the Safety and Health regulations of the U.S. Department of Labor set forth in 29 CFR, Part 1926, and to the Massachusetts Department of Safety and Department of Labor, Division of Occupational Safety "Excavation & Trench Safety Regulation (520 CMR 14.00)" and "Rules and Regulations for the Prevention of Accidents in Construction Operations (454 CMR 10.0 et seq.)." Contractors shall be familiar with the requirements of these regulations.
- B. The Contractor is responsible for the adequacy of the excavation support system and shall retain the services of a Professional Engineer registered in the state where the project is located to design the required excavation support systems. The Contractor's Professional Engineer shall practice in a discipline applicable to excavation work, shall have experience in the design of excavation support systems and shall design in conformance with OSHA requirements. The Contractor's Professional Engineer shall provide sufficient on-site inspection and supervision to assure that the excavation support system is installed and functions in accordance with its design. Criteria listed herein defining the responsibilities of the Contractor's Professional Engineer are minimum requirements.

1.04 REFERENCES:

The following standards form a part of this specification as referenced herein.

ASTM International (ASTM)

ASTM	A6	Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM	A328	Standard Specification for Steel Sheet Piling

1.05 SUBMITTALS:

- A. At least three weeks before starting installation of the excavation support system, the Contractor shall submit the attached Certificate of Design completed and signed by the Contractor and the Professional Engineer, identifying the Contractor's Professional Engineer who will be responsible for design of the excavation support system, and in accordance with Section 01 33 23, including, for record purposes only:
 1. An overall time schedule for construction of the braced excavation system.
 2. A description of the anticipated sequence of construction.
 3.
 - a. Complete details of braced excavation methods, equipment and sizes and lengths of materials proposed to be used.
 - b. Details of vibration monitoring devices and reports.
 - c. Details of the means and methods that will be used in monitoring the integrity of the support system during its entire period of use to ensure the safety of the excavation.
 - d. Complete computations for the design of the braced excavation system bearing the seal of the responsible Professional Engineer duly registered licensed to practice within a discipline applicable to excavation work, in the state where the project is located.
 - e. Any other pertinent data required for record purposes by the Engineer.
- B. Receipt of the information by the Engineer will not relieve the Contractor of the sole responsibility for the adequacy of the braced excavation system, and for assuring that there will be no resulting damage to adjacent pavement, utilities or structures, and for providing safe conditions within the sheeted areas.
- C. Further for the record, upon completion of the work of this section, the Contractor shall submit all records of survey, vibration monitoring and inspection of existing structures to the Owner's Engineer.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Timber sheeting shall be sound spruce, pine, or hemlock, and either tongue and grooved or splined. Timber sheeting shall not be less than nominal 2-inches thick.
- B. Where steel sheet piling is indicated on the drawings or installation is ordered by the Engineer or required by OSHA standards, the material shall be of such size and strength as required by the excavation support design prepared and submitted by the Contractor's Professional Engineer.

Steel sheet piling may be new or used material but shall not contain splices, cutouts, patches, or other alterations which would impair its integrity or strength. Steel sheeting shall be an approved standard section, weighing not less than 22 pounds per square foot of wall and conforming to ASTM A6 and A328.

- C. Where soldier piles and lagging are used, the steel piles shall conform to ASTM A6, and the lagging shall meet the requirements for timber sheeting, as defined above.
- D. Timber and steel used for bracing shall be of such size and strength as required in the excavation support design prepared and submitted by the Contractor's Professional Engineer. Timber or steel used for bracing shall be new or undamaged used material, which does not contain splices, cutouts, patches, or other alterations, which would impair its integrity or strength.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Work shall not be started until all materials and equipment necessary for construction are either on the site of the work or satisfactorily available for immediate use as required.
- B. The sheeting/lagging shall be sufficiently tight to minimize any resulting lowering of the groundwater level outside the excavation, as required in Section 31 23 19, DEWATERING.
- C. The sheeting/piling shall be driven by approved means to the design elevation. No ends or edges of sheeting/piling shall be left exposed in a manner, which could create a possible hazard to the safety of the public or a hindrance to traffic of any kind.
- D. If boulders or very dense soils are encountered, making it impractical to drive a sheeting/piling section to the desired depth, the section shall be treated as directed by the Contractor's Engineer.
- E. Within seven days of completing the initial installation of the earth support system, the Contractor shall submit a certification from its Professional Engineer, stating that the excavation support system as installed is in general compliance with the design or approved modifications thereto.
- F. The sheeting/piling shall be left in place where indicated on the drawings or required by the Engineer in writing. At all other locations, the sheeting/piling may be left in place or salvaged at the option of the Contractor. Wood or steel sheeting/piling permanently left in place shall be cut off at a depth of not less than two feet below finish grade unless otherwise required.
- G. All cut-off material is the property of the Contractor and shall be promptly removed by it from the site.
- H. The satisfactory construction and maintenance of the excavation support system, complete in place, shall be the responsibility of the Contractor.
- I. The Contractor shall be responsible for promptly repairing all damage to adjacent structures caused by the installation, performance, or removal of the excavation support system.

END OF SECTION

(Certificate of Design follows this page)

CERTIFICATE OF DESIGN

RE: Contract between
OWNER:
and (Name)
CONTRACTOR:
on (Name)
CONTRACT:
(Title)
(Number) (Date)

The undersigned hereby certify that the engineer listed below:

1. Is licensed or registered to perform professional engineering work in the state of ;
(Location of Project)
2. Is qualified by education and training to design the
specified in Section of subject contract;
3. Has previously designed comparable excavation support systems;
4. Has prepared the design in full compliance with the requirements of subject contract, including all applicable laws, regulations, rules, and codes; and
5. Will inspect and supervise installation of the excavation support system and will monitor the in-place system to confirm that the system is installed and functions in accordance with the design.

CONTRACTOR

ENGINEER

By:

(Signature)

(Name)

(Title)

(Date)

By:

(Signature)

(Name)

(Engineering Discipline)

(Date)

SECTION 32 11 00

SIDEWALK CONSTRUCTION AND REPLACEMENT

PART 1 - GENERAL

1.01 WORK INCLUDED:

The Contractor shall furnish all labor, materials, equipment and incidentals required to restore gravel sidewalks and/or construct new or replacement hot mix asphalt or cement concrete sidewalks where directed or where existing sidewalks are disturbed by the Contractor, as shown on the drawings and described herein. The Contractor shall also furnish all materials and install pedestrian curb ramps where shown on the drawings or as required by the Engineer.

1.02 RELATED WORK:

- A. Section 31 00 00, EARTHWORK
- B. Section 32 16 00, CURBING

1.03 REFERENCES:

The following standards form a part of these specifications, as referenced:

Massachusetts Department of Transportation (MassDOT)
Standard Specifications for Highways and Bridges

Section 701 Cement Concrete Sidewalks, Pedestrian Curb Ramps and Driveways

Section 702 Hot Mix Asphalt Sidewalks and Driveways

Code of Massachusetts Regulations (CMR)

521 CMR 24 Ramps

1.04 SUBMITTALS:

- A. In accordance with Section 01 33 23 SUBMITTALS the Contractor shall submit shop drawings and/or materials specifications for each component of the work to be performed under this section of the Specifications.

1.05 SYSTEM DESCRIPTION:

- A. CEMENT CONCRETE SIDEWALKS, PEDESTRIAN CURB RAMPS AND WHEELCHAIR RAMPS:

1. Except as otherwise indicated, cement concrete sidewalks, pedestrian curb ramps, and wheelchair ramps shall be constructed in accordance with the requirements of Sections 701 and 702 of the latest edition of the MassDOT Standard Specifications for Highways and Bridges, and all amendments thereto.
 2. Pedestrian curb ramps and wheelchair ramps shall be installed in new sidewalks at intersections in accordance with 521 CMR 24 and Mass DOT Section 701. When curbs or sidewalks are constructed or reconstructed on one side of the street, curb cuts shall also be installed on the opposite sides of the street, where there is a pedestrian path of travel. Curb cuts shall be located within the crosswalk and/or the pedestrian path of travel.
- C. Water boxes, manhole frames, and all other castings shall be carefully set to the proposed finished grade.
- D. Sidewalks shall not be less than 48-inches in width, excluding curbing. An unobstructed path of travel shall be provided which is at least 36-inches clear, excluding curbing.

PART 2 - PRODUCTS

2.01 CEMENT CONCRETE SIDEWALKS AND WHEELCHAIR RAMPS:

- A. Cement concrete sidewalks shall be constructed with air entrained Cement Concrete with a minimum compressive strength of 4000 psi at 28 days.
- B. Cement concrete shall conform to the requirements of MassDOT M4.02.

PART 3 - EXECUTION:

3.01. CEMENT CONCRETE SIDEWALKS AND PEDESTRIAN CURB RAMPS:

- A. Concrete for sidewalks and pedestrian curb ramps shall be a minimum of 4-inches thick. At driveways, the sidewalks shall be 6-inches thick.
- B. The subgrade for the walk or driveway shall be shaped to a true surface conforming to the proposed slope of the walk, thoroughly rolled at optimum moisture content and tamped with a power roller weighing not less than one ton and not more than 5 tons. All depressions occurring shall be filled with suitable material and again rolled or tamped until the surface is smooth and hard.
- C. After the subgrade has been prepared as hereinbefore specified, a subbase of dense graded crushed stone at optimum moisture content shall be placed, thoroughly rolled by a power roller, and tamped. The dense graded crushed stone shall be a minimum of 8-inches in thickness.

- D. The forms for sidewalks shall be smooth, free from warp, strong enough to resist springing out of shape, and deep enough to conform to the thickness of the proposed walk. All mortar or dirt shall be completely removed from forms that have been previously used. The forms shall be well staked, thoroughly braced, and set to the established lines with their upper edge conforming to the grade of the finished walk. The finished walk shall have sufficient pitch from the outside to the edge of the walk to provide for surface drainage. This pitch shall be $\frac{1}{4}$ -inch per foot unless otherwise directed by the Engineer. Before the concrete is placed, the subbase for sidewalks shall be thoroughly dampened until it is moist throughout but without puddles of water.
- E. Concrete shall be conveyed from the place of mixing to the place of deposit in such a manner that no mortar will be lost, and the composition of the mix shall be uniform, showing neither excess nor lack of mortar in any one place. The consistency shall be such that water will float to the surface under heavy tamping. The concrete shall be placed as close to its final position as practicable and thoroughly consolidated, with precautions taken not to overwork it while it is still plastic. The concrete shall be thoroughly spaded along the forms or screeds to eliminate voids and honeycombs at the edges. Retempering of concrete will not be permitted.
- F. Concrete shall be placed in alternate slabs not exceeding 30 feet in length. Slabs shall be separated by transverse preformed expansion joint filler $\frac{1}{2}$ -inch thick. The surface of all concrete sidewalks shall be uniformly scored into block units of not more than 40 square feet. The depth of the scoring shall be at least one quarter of the thickness of the sidewalk.
- G. When concrete sidewalks are constructed adjacent to curbing, building foundations, retaining walls, light pole bases or fixed structures, $\frac{1}{2}$ -inch thick premolded joint filler shall be used between the newly constructed sidewalk and the structure.
- H. Finishing of the concrete surface shall be done by experienced and competent cement finishers as soon as is practicable. Finishing shall be delayed until all bleed water and water sheen has left the surface and the concrete has begun to stiffen. The concrete surface shall be finished as directed with a steel trowel or wood float to give a smooth, uniform and attractive surface finish and uniformly scored into block units or areas of not more than 36 square feet. Following this, the Contractor shall draw a nylon push broom lightly over the surface to produce a non-slip surface. Application of neat cement to the surface to hasten hardening is prohibited.
- I. The Contractor shall protect the newly placed concrete surface against vandalism and marking or defacing and must stand ready to replace any blocks which, in the opinion of the Engineer, are excessively marked or defaced, at no additional cost to the Owner. When completed the walks shall be kept moist and protected from traffic and weather for at least 3 days.
- J. Adequate protection shall be provided where temperatures of 40°F or lower occur during placing of concrete and during the early curing period. The minimum temperature of fresh concrete after placing and for the first 3 days shall be maintained above 55°F. In

addition to the above requirements, an additional 3 days of protection from freezing shall be maintained.

END OF SECTION

SECTION 32 12 00

PAVING

PART 1 - GENERAL

1.01 WORK INCLUDED:

The Contractor shall furnish all labor, materials and equipment and shall replace the pavements as indicated on the drawings and as herein specified.

1.02 RELATED WORK:

- A. Section 00 31 43, PERMITS
- B. Section 01 14 19.16, DUST CONTROL
- C. Section 31 00 00, EARTHWORK
- D. Section 33 39 13, PRECAST MANHOLES AND CATCH BASINS
- E. Section 09 90 00, PAINTING

1.03 SYSTEM DESCRIPTION:

A. GENERAL

The types of pavement systems to be utilized on this project are as follows:

- TYPE 1. TEMPORARY TRENCH PAVEMENT
- TYPE 2. PERMANENT TRENCH PAVEMENT
- TYPE 3. HEAVY DUTY PERMANENT PAVEMENT
- TYPE 4. LIGHT DUTY PERMANENT PAVEMENT

PAVEMENT SCHEDULE

B. TYPE 1. TEMPORARY TRENCH PAVEMENT

Areas shall be paved with temporary trench pavement consisting of 2 inch binder and 2 inch top course, as soon as practicable after installation of utilities. Temporary pavement shall be maintained a minimum of 90 days or for at least one season freeze/thaw cycle prior to installation of permanent pavement. This may require that the temporary pavement be maintained until the following year, at which time the permanent pavement shall be installed.

C. TYPE 2. PERMANENT TRENCH PAVEMENT

Areas shall be milled 12 inches horizontally beyond the limits of temporary trench pavement to a depth of 2 inches and overlaid with top course pavement, the thickness of which is designated in the pavement section detail within the Drawings. Permanent pavement shall be installed only with the approval of the Engineer.

D. TYPE 3. HEAVY DUTY PERMANENT PAVEMENT

Driveways and all other heavy truck traffic areas shall be paved with permanent curb to curb base course pavement and permanent curb to curb top course pavement, with course thicknesses as specified by the pavement section detail within the Drawings.

E. TYPE 4. LIGHT DUTY PERMANENT PAVEMENT

Parking areas, as specified on the Drawings, shall be paved with permanent curb to curb base course pavement and top course pavement, with course thicknesses as specified by the pavement section detail within the Drawings.

1.04 REFERENCES:

The following standards form a part of these specifications and indicate the minimum standards required:

ASTM International (ASTM)

ASTM D1557	Test for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10 Pound Rammer and 18-Inch Drop

Massachusetts Department of Transportation (MassDOT)
Standard Specifications for Highways and Bridges

MassDOT 401	Gravel Sub-base Course
MassDOT 402	Dense Graded Crushed Stone for Sub-base
MassDOT 403	Reclaimed Base Course
MassDOT 405	Gravel Base Course
MassDOT 420	Hot Mix Asphalt Base Course
MassDOT 460	Hot Mix Asphalt Pavement
MassDOT 476	Cement Concrete Pavement
MassDOT 860	Reflectorized Pavement Markings

Federal Specifications

SS-S-1401

Sealants, Joint, Non-Jet-Fuel-Resistant, Hot Applied, for Portland Cement and Asphalt Concrete Pavement

AASHTO Standard Specifications for Materials and Methods of Sampling and Testing

1.05 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 23
SUBMITTALS, SUBMIT THE FOLLOWING:

Complete job mix formula shall be submitted to the Engineer at least two weeks before any of the work of this section is to begin.

PART 2 - PRODUCTS

2.01 STATE HIGHWAY TRENCH REPAIR:

(Not Applicable)

2.02 GRAVEL SUBBASE:

- A. Gravel subbase shall consist of inert material that is hard durable stone and coarse sand, free from loam and clay, surface coatings and deleterious materials.
- B. Gradation requirements for gravel subbase shall be as specified in Section 31 00 00, EARTHWORK for Gravel Borrow.

2.03 RECLAIMED SUBBASE:

(Not Applicable)

2.04 HOT MIX ASPHALT PAVEMENT:

- A. Pavements shall consist of hot mix asphalt.
- B. Pavement mixtures shall be within the composition limits of base courses, binder courses, top courses, in accordance with MassDOT M3.11.03, with constituents that conform to SUPERPAVE as specified in current MassDOT Standard Specifications.
- C. The joint sealant shall be a hot poured rubberized emulsified asphalt sealant meeting the requirements of FS SS-S-1401.
- D. The tack coat shall be an asphalt emulsion, RS-1 if required, conforming to MassDOT Section M3.03.0.

2.05 SEAL COAT:

- A. Seal coats shall be within the composition limits for protective seal coat emulsion in accordance with MassDOT M3.03.3.
- B. Silica sand when blended with seal coat emulsion shall be No. 30 silica sand.

2.06 PAVEMENT MARKINGS:

- A. Pavement markings shall conform to the requirements of MassDOT 860.
- B. The mixture of the marking material shall be within the composition limits for reflectorized pavement markings as described in the MassDOT Specifications as follows:
 - 1. Thermoplastic reflectorized pavement markings - M7.01.03/04.
- C. Application of the glass beads to be used as reflector material on the striping shall conform to Sections 860.62 and M7.03.07 of the MassDOT Specifications.

2.07 PAINT FOR PARKING LOTS

- A. Paint for parking lot lines shall conform to Federal Specification TT-P-115-E Type 1. Paint shall be 11-3 PPG Industries, Pittsburgh, PA or approved equal.

PART 3 - EXECUTION

3.01 GENERAL:

Paving courses required for the project shall be as shown on the drawings and as specified herein. Pavement thicknesses specified are measured in compacted inches. If a pavement course thickness exceeds 2-1/2 compacted inches, the course shall be installed in multiple lifts with each lift not exceeding 2-1/2 compacted inches in thickness.

3.02 STATE HIGHWAY TRENCH REPAIR:

(Not Applicable)

3.03 GRAVEL SUBBASE:

- A. The gravel subbase to be placed under pavement shall consist of gravel evenly spread and thoroughly compacted, with a course thickness as specified by the typical pavement section detail in the Drawings.
- B. The material shall be spread in layers not more than 4-inches thick, compacted measure. All layers shall be compacted to not less than 95 percent of the maximum dry density of the material as determined by ASTM D1557 Method C at optimum moisture content.

3.04 RECLAIMED SUBBASE:

- A. (Not Applicable)

3.05 TEMPORARY BITUMINOUS PAVEMENT:

- A. Where specified and required by the Engineer and after placement of the gravel subbase, the Contractor shall place temporary bituminous pavement above the trench, between the edges of the existing pavement. It shall consist of hot mix asphalt, **2-inches** thick, in accordance with MassDOT 460.
- B. The temporary pavement shall be repaired as necessary to maintain the surface of the pavement until replaced by permanent pavement. When so required by the Engineer, the Contractor shall remove the temporary pavement and install or regrade the subbase for installation of permanent pavement.

3.06 PERMANENT BITUMINOUS PAVEMENT:

- A. The bituminous paving mixture, equipment, methods of mixing and placing, and the precautions to be observed as to weather, condition of base, etc., shall be in accordance with MassDOT 460.
- B. BASE COURSE AND BINDER COURSE PAVEMENT:
 - 1. Immediately prior to installing the base and binder courses, the trimmed edges shall be made stable and unyielding, free of loose or broken pieces and all edges shall be thoroughly broomed clean. Contact surfaces of trench sides, curbs, manholes, catch basins, or other appurtenant structures in the pavement shall be painted thoroughly with a uniform coating of asphalt emulsion (tack coat), just before any mixture is placed against them.
 - 2. The binder course shall be repaired as necessary to maintain the surface of the pavement until placement of the permanent overlay. If required, the Contractor shall place a leveling course before placing the permanent overlay.
- C. TOP COURSE:
 - 1. Top course shall be placed over the trench or full width as shown on the drawings or as specified.
 - 2. Prior to placement of the top course, the entire surface over which the top course is to be placed shall be broom cleaned and tack coated.
 - 3. Top course pavement placed over trenches may be feathered to meet existing paved surfaces, if approved by the Engineer.
 - 4. Prior to placing full width top course, keyways shall be cut in all intersecting streets.

3.07 PAVEMENT PLACEMENT:

- A. Unless otherwise permitted by the Engineer for particular conditions, only machine methods of placing the pavement shall be used. The equipment for spreading and finishing shall be mechanical, self-powered pavers, capable of spreading and finishing the mixture true to line, grade, width and crown. The mixtures shall be placed and compacted only at such times as to permit proper inspection and checking by the Engineer.
- B. After the paving mixtures have been properly spread, initial and intermediate compaction shall be obtained by the use of steel wheel rollers having a weight of not less than 240 pounds per inch width of tread.
- C. Final rolling of the top course pavement shall be performed by a steel wheel roller weighing not less than 285 pounds per inch width of tread at a mix temperature and time sufficient to allow for final smoothing of the surface and thorough compaction.
- D. Immediately after placement of top course pavement, all joints between the existing and new top course or surface treatment pavements shall be sealed with hot poured rubberized asphalt joint sealant.
- E. Where there is no backing for the edges of the curb-to-curb pavement, the Contractor shall provide a gravel transition. The gravel transition shall be installed immediately after the pavement is placed, shall be feathered and extend a minimum of 18-inches, and shall be compacted using the same equipment as for pavement compaction. The gravel shall be uniformly graded material with a maximum size of 3/8- to 1/2-inch.
- F. When required by the Engineer, the Contractor shall furnish and install additional paving to provide satisfactory transition for driveways and walkways impacted by a new curb-to-curb pavement installation. The transition installation will be considered incidental to the curb-to-curb pavement installation.

3.08 ADDITIONAL PAVING:

- A. If the Engineer determines that the existing bituminous concrete pavement on local streets is thicker than the permanent pavement specified herein, the Contractor may be required to install hot mix asphalt to obtain the depth of the existing pavement.
- B. If for the installation of full width paving, the Engineer determines that the existing road surface requires additional leveling pavement, then the Contractor shall install additional hot mix asphalt to bring the section to proper line and cross section. Additional paving required to restore the proper line and cross section of binder course installed by the Contractor which has become rough and uneven shall be furnished and installed at the expense of the Contractor.

3.09 LIGHT DUTY AND HEAVY DUTY PAVEMENT:

- A. Light Duty Pavement and Heavy Duty Pavement shall be as specified above and indicated on the Drawings. All layer thicknesses specified on the Drawings are compacted thicknesses.
- B. Adjacent concrete work, slate work, sidewalks, structures, etc., shall be protected from stain and damage during the entire operation. Damaged or stained areas shall be replaced or repaired to equal their original condition.
- C. All joints between binder and top course shall be staggered a minimum of 6-inches.
- D. After final rolling, no vehicular traffic of any kind shall be permitted on the pavement until it has cooled and hardened sufficiently to prevent distortion and loss of fines, and in no case in less than 6 hours.
- E. Smoothness of all areas of the finished surface shall not vary more than 1/4-inch when tested with a 16 foot straight-edge, applied both parallel to and at right angles to the centerline of the paved area. At building entrances, curbs, and other locations where an essentially flush transition is required, pavement elevation tolerance shall not exceed plus or minus 1/8-inch. Irregularities exceeding these amounts, or which retain water on the surface, shall be corrected by removing the defective work and replacing or repairing it to the satisfaction of the Engineer.
- G. The Contractor shall prepare the pavement surface for painting lines according to the recommendations of the paint manufacturer. Applied markings shall have clean-cut edges, true and smooth alignment and uniform film thickness of 15 mils, +/- 1.0. The Contractor shall be responsible for removing, to the satisfaction of the Engineer, tracing marks, and spilled paint applied in an unauthorized area.

3.10 RAISING AND ADJUSTING CASTINGS:

- A. In areas of permanent top course paving, existing municipally-owned catch basin and manhole castings and valve boxes shall be raised to the proper grade where required by the Engineer.
- B. Castings owned by private utilities shall be raised by their own forces. The Contractor shall be responsible for coordinating this work.
- C. The method of adjusting these castings shall be as follows: Cut around catch basin or manhole castings a minimum of 8-inches from casting. Excavate and if required rebuild up to 12-inches of masonry below the bottom of the casting. Backfill with suitable material and compact to bottom of casting. Place high, early strength cement or bituminous concrete collar, as directed, to approximately 1½-inches below the raised casting grade. Masonry work shall conform to Section 33 39 13, PRECAST MANHOLES AND CATCH BASINS.

- D. In some areas, raising of castings may not be required. Where required by the Engineer, castings not to be raised shall have at least 12-inches of bituminous concrete pavement chipped and removed around the casting. New bituminous concrete pavement shall be placed and compacted around such castings to approximately 1-1/2-inches below the top of the casting. The overlay course shall then be sloped down to the level of the casting.
- E. The method of raising valve boxes shall be as follows: Cut around valve box a minimum of 8-inches from valve box. Excavate as required and raise the valve box. Pour high early strength cement or bituminous concrete collar, as directed, to approximately 1-1/2-inches below the top of the valve box.
- F. Castings which need to be raised or adjusted to complete permanent curb to curb paving shall be done immediately prior to paving.

3.11 PAVEMENT MARKINGS:

- A. The Contractor shall replace all pavement markings removed or covered-over in carrying out the work, and as required by the Engineer, no sooner than 48 hours after completion of permanent pavement. The markings shall be 4-inches wide, white or yellow, single or double lines as required.
- B. When required by the Engineer, the Contractor shall provide temporary markings at no additional cost to the Owner.

3.12 PAVEMENT REPAIR:

- A. If required in the contract or if permanent pavement becomes rough or uneven, permanent pavement patches and trenches shall be repaired and brought to grade utilizing "infrared" paving methods following completion of the construction.
- B. The Contractor performing the work shall use care to avoid overheating the pavement being repaired.
- C. Pavement repair shall extend a minimum of 6-inches beyond all edges of the pavement patch to assure adequate bonding at the pavement joints.

END OF SECTION

SECTION 32 16 00

CURBING

PART 1 - GENERAL

1.01 WORK INCLUDED:

- A. This section covers furnishing and installation of granite curb, hot mix asphalt curb and precast parking curb, where required, as shown on the Drawings and herein specified.
- B. This section also covers replacement of curbing removed during construction.

1.02 RELATED WORK:

- A. Required earthwork is specified under Section 31 00 00 EARTHWORK.
- B. Section 32 12 00, PAVING.
- C. Section 32 11 00, SIDEWALK CONSTRUCTION AND REPLACEMENT

1.03 REFERENCES:

The following standards form a part of these specifications, as referenced:

Massachusetts Department of Transportation (MassDOT) Standard Specifications for Highways and Bridges

1.04 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 23 SUBMITTALS, SUBMIT THE FOLLOWING:

Shop drawings, showing dimensions of typical curb sections.

PART 2 - PRODUCTS

2.01 GRANITE CURBING:

- A. Granite curbing shall be Type VAI conforming to Subsection M9.04.1 of the latest edition of the MassDOT Standard Specifications for Highways and Bridges.
- B. Special shapes and corners shall be supplied as required.

2.02 GRANITE EDGING:

- A. Granite edging shall be Type SB conforming to Subsection M9.04.2 of the latest edition of the MassDOT Standard Specifications for Highways and Bridges.

- B. Special shapes and corners shall be supplied as required.

2.03 HOT MIX ASPHALT BERM

Berm shall conform to Subsection M3.11.6 of the latest edition of the MassDOT Standard Specifications for Highways and Bridges.

PART 3 - EXECUTION

3.01 GRANITE CURBING:

- A. Removal and resetting and/or removal and replacing of granite curbing shall be in accordance with Subsection 580 of the latest edition of the MassDOT Standard Specifications for Highways and Bridges. The curbing shall have a 6-inch reveal unless otherwise required by the Engineer.
- B. Except as modified herein or on the drawings, installation of curbing shall conform to Section 500 of the MassDOT Standard Specifications for Highways and Bridges.
- C. Excavation shall be made to the bottom of the 6-inch gravel base below the curbing, the trench being sufficiently wide to permit thorough tamping. The base shall be compacted to a firm, even surface and shall be approved by the Engineer.
- D. The curbing shall be set on edge and settled into place with a heavy wooden hand-rammer, to the line and grade required, straight and true for the full depth. The joints of the stone curbing shall be pointed with mortar for the full depth of the curbing. At approximately 50-foot intervals, a 1/2-inch joint shall not be filled with mortar but left free for expansion. The ends of the stone curbing at driveways and intersections shall be cut at a bevel or rounded as required by the Engineer.
- E. The trench for the stone curbing shall be backfilled with approved material; the first layer to be 4 inches in depth, thoroughly rammed; the other layers to be more than 6 inches in depth and thoroughly rammed until the trench is filled.
- F. Where indicated on the plans, or as required, drainage openings shall be made through the curbing at the elevations and of the size required.

3.02 GRANITE EDGING:

- A. Except as modified herein and on the drawings, installation of granite edging shall conform to Section 500 of MassDOT Standard Specifications for Highways and Bridges.
- B. The cement concrete base shall be placed on a well-tamped sub-base acceptable to the Engineer, and shall be constructed of 3000 psi concrete, minimum, as shown on the drawings.

- C. The edging shall be set to the proper lines and grades on the concrete base and on a well-tamped sloping gravel surface.

3.03 HOT MIX ASPHALT BERM:

- A. Replacement of hot mix asphalt berm shall be in accordance with Section 500 of the latest edition of the MassDOT Standard Specification for Highways and Bridges and all amendments thereto. The berm shall have a 3-inch reveal unless otherwise required by the Engineer.
- B. Unless modified herein, installation shall conform to Section 501.64 of the MassDOT Standard Specifications for Highways and Bridges.
- C. When indicated on the plans, or as directed, drainage openings shall be made through the berm at the elevations and of the size required.

END OF SECTION

SECTION 32 91 19

LOAMING AND SEEDING

PART 1 - GENERAL

1.01 WORK INCLUDED:

This section covers all labor, materials, and equipment necessary to do all loaming, seeding and related work as indicated on the drawings and as herein specified. All lawns disturbed by the Contractor's operations shall be repaired as herein specified.

The Contractor shall bear the responsibility and cost of furnishing and applying water or any other substances, as necessary to ensure the establishment and satisfactory growth of seeded turf areas, as part of the work of this contract, until acceptance by the Engineer.

1.02 RELATED WORK:

- A. Section 32 93 00, TREES, SHRUBS, GROUNDCOVERS, AND LANDSCAPING

1.03 QUALITY ASSURANCE:

- A. For a particular source of loam, the Engineer may require the Contractor to send approximately 10 pounds of loam to an approved testing laboratory and have the following tests conducted:

1. Organic concentration
2. pH
3. Nitrogen concentration
4. Phosphorous concentration
5. Potash concentration

- B. These tests shall be at the Contractor's expense. Test results, with soil conditioning and fertilizing recommendations, shall be forwarded to the Engineer.

1.04 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 23 SUBMITTALS, SUBMIT THE FOLLOWING:

- A. Information detailing the seed mixes, fertilizers, mulch material, slope protection material (if required) and origin of loam.
- B. Test results.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. LOAM:

1. Loam shall be a natural, fertile, friable soil, typical of productive soils in the vicinity, obtained from naturally well-drained areas, neither excessively acid nor alkaline, and containing no substances harmful to grass growth. Loam shall not be delivered to the site in frozen or muddy condition and shall be reasonably free of stumps, roots, heavy or stiff clay, stones larger than 1-inch in diameter, lumps, coarse sand, noxious weeds, sticks, brush or other litter.
2. The loam shall contain not less than 4 percent or more than 20 percent organic matter as determined by the loss of weight by ignition of oven-dried samples. Test samples shall be oven-dried to a constant weight at a temperature of 230 degrees F.

B. LIME:

Lime shall be standard commercial ground limestone containing at least 50 percent total oxides (calcium oxide and magnesium oxide), and 50 percent of the material must pass through a No. 100 mesh sieve with 98 percent passing a No. 2 mesh sieve.

C. FERTILIZER:

Fertilizer shall be commercial fertilizer, 10-10-10 fertilizer mixture containing at least 40 percent of organic, slow-release nitrogen. It shall be delivered to the site in the original sealed containers, each showing the manufacturer's guaranteed analysis. Fertilizer shall be stored so that when used it will be dry and free flowing. No fertilizer shall be used which has not been marketed in accordance with State and Federal Laws, relating to fertilizers.

D. MULCH:

1. Materials to be used in mulching shall conform to the following requirements:
2. Straw Mulch - Straw Mulch shall consist of stalks or stems of grain after threshing. Hay mulch shall not be accepted.
3. Wood Fiber Mulch - Wood Fiber Mulch shall consist of wood fiber produced from clean, whole uncooked wood, formed into resilient bundles having a high degree of internal friction and shall be dry when delivered to the project.

E. SEED:

1. Seed shall be of an approved mixture, the previous year's crop, clean, high in germinating value, a perennial variety, and low in weed seed. Seed shall be

obtained from a reliable seed company and shall be accompanied by certificates relative to mixture purity and germinating value.

2. Grass seed for lawn areas shall conform to the following requirements:

	Proportion by Weight	Germination Purity	Purity Minimum
Chewing's Fescue	30%	70%	97%
Kentucky 31 Fescue	30%	90%	98%
Kentucky Blue Grass	20%	80%	85%
Domestic Rye Grass	20%	90%	98%

3. Erosion Control Seed Mix: Grass and forbs seed mix for cross-country areas, slopes and other areas not normally mowed shall conform to the following requirements:

	Proportion by Weight	Germination Minimum	Purity Minimum
Creeping Red Fescue	50%	85%	95%
Kentucky 31	30%	85%	95%
Domestic Rye	10%	90%	98%
Red Top	5%	85%	92%
Ladino Clover	5%	85%	96%

4. Wetland Seed Mix: Grass and forbs seed mix for wetland restoration and mitigation, shall conform to the following requirements: seeded at 20 lb per acre or ½ lb per 1000 sq ft with a cover crop of grain rye or recommended seed mix by seed producer, depending upon the time of year when seeding. Seed mix shall be

the ***OBL-FACW Perennial Food & Cover Wetland Mix – ERNMX-120***, by ERNST Seeds, Meadville, PA, or approved equal.

Mix	Botanical Name	Common Name
22.10 %	Carex scoparia, PA Ecotype	Blunt Broom Sedge, PA Ecotype
22.00 %	Carex lurida, PA Ecotype	Lurid Sedge, PA Ecotype
20.00 %	Elymus virginicus, NY Ecotype	Virginia Wildrye, Madison-NY Ecotype
17.80 %	Carex vulpinoidea, PA Ecotype	Fox Sedge, PA Ecotype
10.00 %	Panicum clandestinum,	Tioga Deertongue, Tioga
3.00 %	Juncus effusus	Soft Rush
2.00 %	Leersia oryzoides, PA Ecotype	Rice Cutgrass, PA Ecotype
1.00 %	Glyceria striata, PA Ecotype	Fowl Mannagrass, PA Ecotype
0.50 %	Carex crinita, PA Ecotype	Fringed Sedge, PA Ecotype
0.50 %	Juncus tenuis, PA Ecotype	Path Rush, PA Ecotype
0.50 %	Scirpus cyperinus, PA Ecotype	Woolgrass, PA Ecotype
0.30 %	Scirpus atrovirens, PA Ecotype	Green Bulrush, PA Ecotype
0.20 %	Carex stipata, PA Ecotype	Awl Sedge, PA Ecotype
0.10 %	Carex stricta, PA Ecotype	Tussock Sedge, PA Ecotype

F. TEMPORARY COVER CROP:

1. Temporary cover crop shall conform to the following requirements:

	% Weight	Germination Minimum
Winter Rye	80 min.	85%
Red Fescue (creeping)	4 min.	80%
Perennial Rye Grass	3 min.	90%
Red Clover	3 min.	90%
Other Crop Grass	0.5 max.	
Noxious Weed Seed	0.5 max.	
Inert Matter	1.0 max.	

G. SLOPE EROSION PROTECTION:

1. Erosion control blanket shall be 100% degradable plastic mesh with 100% degradable straw or straw/coconut fill. Fill shall be held together by degradable fastening. Weight shall be 0.50 lb. /sq. yd. Erosion control blankets shall be applied parallel to direction of water flow. The erosion control blankets shall be by

North American Green, Evansville, IN or approved equal. For slopes 2:1 or greater, Model SC150 shall be used. For slopes less than 2:1, Model S150 shall be used.

2. Six inch wire staples shall be placed according to manufacturer's recommendations to anchor the mesh material. Staples shall be designed to decompose.

PART 3 - EXECUTION

3.01 SURFACE PREPARATION:

- A. After approval of rough grading, loam shall be placed on areas affected by the Contractor's operations. Loam shall be at least 6-inches compacted thickness.
- B. Lime shall be applied to bring the pH to 6.5 or, without a soil test, at the rate of 2-3 tons of lime per acre.
- C. Fertilizer shall be applied according to the soil test, or without a soil test, at the rate of 1000 pounds per acre.
- D. Loam shall be worked a minimum of 3-inches deep, thoroughly incorporating the lime and fertilizer into the soil. The loam shall then be raked until the surface is finely pulverized and smooth and compacted with rollers, weighing not over 100 pounds per linear foot of tread, to an even surface conforming to the prescribed lines and grades. Minimum depth shall be 6-inches after completion.
- E. Limit subgrade preparation to areas that will be planted within 7 days.

3.02 SEEDING:

- A. Seeding shall be done when weather conditions are approved as suitable, in the periods between April 1 and May 30 or August 15 to October 1, unless otherwise approved.
 1. Provide temporary seed and mulch when final grading is complete while waiting for optimal seeding period.
 2. Provide temporary seed and mulch for temporary cover on disturbed ground not to be worked on for more than 7 days.
 3. Provide temporary seed and mulch on disturbed earth prior to temporary shutdown of construction.
- B. If there is a delay in seeding, during which weeds grow or soil is washed out, the Contractor shall remove the weeds or replace the soil before sowing the seed, without

additional compensation. Immediately before seeding is begun, the soil shall be lightly raked.

- C. Seed shall be sown at the approved rate, on a calm day by machine.
- D. One half the seed shall be sown in one direction and the other half at right angles. Seed shall be raked lightly into the soil to a depth of 1/4-inch and rolled with a roller weighing not more than 100 pounds per linear foot of tread.
- E. The surface shall be kept moist by a fine spray until the grass shows uniform germination over the entire area. Wherever poor germination occurs in areas larger than 3 sq. ft., the Contractor shall reseed, roll, and water as necessary to obtain proper germination.
- F. The Contractor shall water, weed, cut and otherwise maintain and protect seeded areas as necessary to produce a dense, healthy growth of perennial lawn grass.
- G. If there is insufficient time in the planting season to complete the fertilizing and seeding, permanent seeding may be left until the following planting season, at the option of the Contractor or as required by the Engineer. In that event, a temporary cover crop shall be sown. This cover crop shall be cut and watered as necessary until the beginning of the following planting season, at which time it shall be plowed or harrowed into the soil, the area shall be fertilized and the permanent seed crop shall be sown as specified.

3.03 PLACING MULCH:

- A. Straw Mulch shall be loosely spread to a uniform depth over all areas designated on the plans, at the rate of 4-1/2 tons per acre, or as otherwise required.
- B. Straw Mulch may be applied by mechanical apparatus, if in the judgment of the Engineer the apparatus spreads the mulch uniformly and forms a suitable mat to control slope erosion. The apparatus shall be capable of spreading at least 80 percent of the hay or straw in lengths of 6-inches or more, otherwise it shall be spread by hand without additional compensation.
- C. Wood Fiber Mulch shall be uniformly spread over certain selected seeded areas at the minimum rate of 1,400 pounds per acre unless otherwise required. It shall be placed by spraying from an approved spraying machine having pressure sufficient to cover the entire area in one operation.

3.04 SEEDING AND MULCHING BY SPRAY MACHINE:

- A. The application of lime, fertilizer, grass seed and mulch may be accomplished in one operation by the use of an approved spraying machine (Hydroseeding). The materials shall be mixed with water in the machine and kept in an agitated state in order that the materials may be uniformly suspended in the water. The spraying equipment shall be so

designed that when the solution is sprayed over an area, the resulting deposits of lime, fertilizer, grass seed and mulch shall be equal to the specified quantities.

- B. A certified statement shall be furnished, prior to start of work, to the Engineer by the Contractor as to the number of pounds of limestone, fertilizer, grass seed and mulch per 100 gallons of water.
- C. This statement should also specify the number of square yards of seeding that can be covered with the solution specified above. If the results of the spray operation are unsatisfactory, the Contractor will be required to abandon this method and to apply the lime, fertilizer, grass seed and mulch by other methods.

3.05 INSPECTION AND ACCEPTANCE:

At the beginning of the planting season following that in which the permanent grass crop is sown, the seeded areas will be inspected. Any section not showing dense, vigorous growth at that time shall be promptly reseeded by the Contractor at their own expense. The seeded areas shall be watered, weeded, cut and otherwise maintained by the Contractor until the end of that planting season, when they will be accepted if the sections show dense, vigorous growth, and coverage of at least 80%.

END OF SECTION

SECTION 33 05 26.13

TRACER TAPE

PART 1 - GENERAL

1.01 WORK INCLUDED:

This section covers the furnishing, handling and installation of tracer tape, as called for on the drawings.

1.02 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 23 SUBMITTALS, SUBMIT THE FOLLOWING:

- A. Manufacturer's literature on the materials, colors and printing specified herein, shall be submitted to the Engineer for review.
- B. Tape samples shall also be submitted to the Engineer for review.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

Tracer tape shall be by Reef Industries, Houston, TX; Empire Level, Mukwonago, WI; Pro-Line Safety Products Co., W. Chicago, IL; or approved equal.

2.02 TRACER TAPE:

- A. Tracer tape shall be at least 3-inches wide.
- B. Tracer tape for non-ferrous pipe or conduit shall be constructed of a metallic core bonded to plastic layers. The metallic tracer tape shall be a minimum 5-mil thick and must be locatable at a depth of 18-inches with ordinary pipe locaters.
- C. Tracer tape for ferrous pipe or conduit shall consist of multiple bonded plastic layers. The non-metallic tracer tape shall elongate at least 500% before breaking.
- D. The tape shall bear the wording: "BURIED DRAIN LINE BELOW" (with "DRAIN" replaced by "WATER", "SEWER", "ELECTRICAL", "GAS", "TELEPHONE", or "CHEMICAL" as appropriate), continuously repeated every 30-inches to identify the pipe.
- E. Tape colors shall be as follows, as recommended by the American Public Works Association (APWA):

Electric	Red
Gas & Oil	Yellow

Communications	Orange
Water	Blue
Sewer & Drain	Green
Chemical	Red (not APWA)

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Tracer tape shall be installed directly above the pipe or conduit it is to identify, approximately 12-inches below the proposed ground surface.
- B. The Contractor shall follow the manufacturer's recommendations for installation of the tape, as approved by the Engineer.

END OF SECTION

SECTION 33 11 13.13

DUCTILE IRON PIPE AND FITTINGS FOR WATER MAINS

PART 1 - GENERAL

1.01 WORK INCLUDED:

This Section covers the furnishing, handling, hauling, laying, jointing, testing and disinfecting of all ductile iron pipe, including fittings and appurtenant work as indicated on the drawings and as specified.

1.02 RELATED WORK:

- A. Section 31 00 00, EARTHWORK
- B. Section 33 11 13.16, WATER SERVICE CONNECTIONS
- C. Section 33 11 13.34, CONNECTIONS TO EXISTING WATER MAINS
- D. Section 33 11 13.43, INSULATION FOR PIPELINES
- E. Section 33 12 22, HYDRANTS AND VALVES

1.03 QUALITY ASSURANCE:

- A. All pipe and fittings shall be inspected and tested at the foundry as required by the standard specifications to which the material is manufactured. The Contractor shall furnish in duplicate to the Engineer sworn certificates of such tests.
- B. In addition, the Owner reserves the right to have any or all pipe, fittings and special castings inspected and/or tested by an independent service at either the manufacturer's plant or elsewhere. Such inspection and/or tests shall be at the Owner's expense.

1.04 REFERENCES:

- A. The following standards, latest version thereof, form a part of this specification as referenced:

American Water Works Association (AWWA)

AWWA	C104	Cement-Mortar Lining for Ductile- Iron Pipe and Fittings
AWWA	C105	Polyethylene Encasement for Ductile Iron Pipe Systems
AWWA	C110	Ductile-Iron and Gray-Iron Fittings Water

AWWA	C111	Rubber Gasket Joints for Ductile- Iron Pressure Pipe and Fittings
AWWA	C116	Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings
AWWA	C150	Thickness Design of Ductile-Iron Pipe
AWWA	C151	Ductile-Iron Pipe, Centrifugally Cast for Water
AWWA	C153	Ductile-Iron Compact Fitting for Water Service.
AWWA	C600	Installation of Ductile-Iron Water Mains & Their Appurtenances
AWWA	C651	Disinfecting Water Mains

1.05 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 23 SUBMITTALS, SUBMIT THE FOLLOWING:

- A. Shop drawings shall be submitted to the Engineer for review.
- B. Shop drawings shall consist of manufacturer's scale drawings, cuts or catalogs including descriptive literature and complete characteristics and specifications, and code requirements. Shop drawings shall be submitted for the ductile iron pipe, type of joint, fittings, couplings, filling rings, restrained joints, and lining and coating in accordance with specifications.

PART 2 - PRODUCTS

2.01 PIPE:

- A. The Contractor shall use push-on joint type ductile iron pipe unless otherwise indicated on the plans or specified herein.
- B. All ductile iron pipe shall be designed in accordance with AWWA C150 and shall be manufactured in accordance with AWWA C151.
- C. Unless otherwise indicated or specified, ductile iron pipe shall be Thickness Class 52.

2.02 JOINTS:

- A. Joints for ductile iron pipe shall conform to AWWA C111.
- B. Pipe and fittings shall be furnished with approved joint restraining appurtenances as specified herein, or within the limits as indicated on the drawings, to keep the piping from pulling apart under pressure.

2.03 FITTINGS:

- A. Fittings shall conform to the requirements of AWWA C110 or C153 as appropriate and shall be of a pressure classification at least equal to that of the pipe with which they are used.
- B. The Contractor shall use ductile iron fittings. Cast-iron, Class 250 fittings may be substituted, upon approval of the Engineer, for ductile iron fittings.
- C. Unless otherwise indicated, fittings shall have all bell mechanical joint ends.

2.04 GASKETS, GLANDS, NUTS AND BOLTS:

- A. Gaskets, glands, nuts, bolts and accessories shall conform to AWWA C111 or C153 as appropriate.
- B. Gaskets shall be of plain tipped rubber, suitable for exposure to the liquid within the pipe.
- C. Glands shall be ductile or cast iron.
- D. Bolts and nuts shall be high strength alloy.

2.05 LINING AND COATING:

- A. The inside of pipe and fittings shall be given a cement lining and asphaltic seal coat in accordance with AWWA C104. The thickness of the lining shall be double that specified in AWWA C104.
- B. The outside of pipe and fittings shall be coated with the standard asphaltic coating specified under the appropriate AWWA Standard Specification for pipe and fittings.
- C. Machined surfaces shall be cleaned and coated with a suitable rust preventative coating at the shop immediately after being machined.

2.06 FLEXIBLE COUPLINGS:

- A. The Contractor shall use solid sleeve coupling fittings for joining pipe. With the approval of the Engineer, sleeve-type flexible couplings may be substituted.
- B. All sleeve-type couplings and accessories shall be of a pressure rating at least equal to that of the pipeline in which they are to be installed.
- C. Couplings shall be cast or ductile iron and shall be provided with gaskets of a composition suitable for exposure to the liquid within the pipe.

- D. Sleeve-type couplings shall be made by Dresser, Bradford, PA; Smith-Blair (a Xylem brand), Texarkana, Arkansas; Romac Industries Inc., Seattle, WA; Ford Meter Box Co., Wabash, IN; or be an approved equal.
- E. Couplings for buried pipe shall be Dresser 138 or 38; Smith-Blair Type 441; Romac Style 501; Ford Style FC1 or FC2W; or approved equal.

2.07 JOINT RESTRAINTS:

- A. Where indicated or necessary to prevent joints or sleeve couplings from pulling apart under pressure, anchoring and joint restraint methods shall be utilized. Methods shall be restrained joint systems. The number of joints to be restrained shall be determined in accordance with Table 1, and as shown on the Drawings.
- B. Restrained joint systems for standard mechanical joint fittings or push on joint pipe shall be restraining glands (Megalug by EBAA Iron Sales Inc., Eastland, TX; StarGrip by Star Pipe Products, Houston, TX; RomaGrip by Romac Industries, Inc., Seattle, WA; Sigma One-Lok by Sigma Corporation, Cream Ridge, NJ; or approved equal) and restraining gaskets (Fast-grip by American Cast Iron Pipe Company, Birmingham, AL; Field Lok 350 Gasket by United States Pipe and Foundry Company, Birmingham, AL; Sure Stop 350 Restrained Joint Gaskets by McWane Ductile, Phillipsburg, NJ; or approved equal). Methods that rely on the use of friction clamps and/or retainer glands with set screws alone are not acceptable.
- C. Restrained joint systems for non-standard or modified joints shall be Flex-Ring or Lok-Ring by American Cast Iron Pipe Company, Birmingham, AL; TR Flex Joint by McWane Ductile, Phillipsburg, NJ; TR-Flex Joint by United States Pipe and Foundry Company, Birmingham, AL; Snap-Lok or Bolt-Lok by United States Pipe and Foundry Company, Birmingham, AL; or approved equal.
- D. Concrete thrust blocks may only be used for 6-inch, 8-inch, 10-inch, or 12-inch pipe where use of a joint restraint system is not feasible. Use of concrete thrust blocks shall be installed with the minimum bearing area (in square feet) against undisturbed material in accordance with the following (Table 1):

Size of Main	90° Bends, Tees, Caps and Plugs	45° Bends and Wyes	22-1/2° Bends	11-1/4° Bends
6- & 8-inch	5	4	2	2
10- & 12-inch	12	9	5	2

- E. Tie rods may only be used for 6-inch, 8-inch, 10-inch, or 12-inch pipe where use of a joint restraint system is not feasible. Bolts shall have adequate length to allow nuts on

both sides of the gland. Tie bolts shall have the same diameter as the tie rods and be in accordance with the following:

Pipe Size	Tie Rod	
	Number	Diameter
6	2	1/2"
8	2	3/4"
10	2	3/4"
12	4	3/4"

- F. Location of restrained joints shall be based on the Drawings. All joints that occur within the restrained length listed in Table 1, for the specific application, shall be restrained. For example, for a 90° bend, 8-inch unwrapped pipe, the restrained length required is 33 feet. Therefore, all joints within 33 feet of the 90° bend must be restrained.

2.08 POLYETHYLENE ENCASEMENT:

- A. The pipe shall be encased in polyethylene conforming to AWWA C105.
- B. Polyethylene encasement shall be either linear low density, minimum 8 mils thick or high density, cross-laminated, minimum 4 mils thick. Polyethylene encasement shall be clearly marked at a minimum of every 2-feet along its length with print that does not contain hazardous material. Markings shall contain manufacturer's name, manufacture year, AWWA C105, minimum film thickness, and 'Warning – Corrosion Protection – Repair any damage.'
- C. Adhesive tape shall be dielectric tape, suitable for use with polyethylene encasement. The use of duct tape shall not be accepted.

PART 3 - EXECUTION

3.01 INSPECTION BEFORE INSTALLATION:

Pipes and fittings shall be subjected to a careful inspection just before being laid or installed.

3.02 HANDLING AND CUTTING:

- A. Any pipe or fitting which has a damaged lining, scratched or marred machine surface and/or abrasion of the pipe coating or lining shall be rejected and removed from the job-site.

- B. Any fitting showing a crack and any fitting or pipe which has received a severe blow that may have caused incipient fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the work.
- C. In any pipe showing a distinct crack and in which it is believed there is no incipient fracture beyond the limits of the visible crack, the cracked portions, if so approved, may be cut off by and at the expense of the Contractor before the pipe is laid so that the pipe used will be perfectly sound. The cut shall be made in the sound barrel at a point at least 12-inches from the visible limits of the crack.
- D. Except as otherwise approved, all cutting shall be done with a machine suitable for cutting ductile iron pipe. Hydraulic squeeze cutters are not acceptable for cutting ductile iron pipe. Travel type cutters or rotary type abrasive saws may be used. All cut ends shall be examined for possible cracks caused by cutting.
- E. Lined and coated pipe and fittings shall be assembled and installed with approved packing or gaskets of the type recommended by the pipe manufacturer for the particular lining used.

3.03 INSTALLATION:

A. DEPTH:

1. The pipe shall be installed with a minimum of 5'-0" of cover, unless specifically indicated otherwise on the Drawings or required by the Engineer.
2. Where pipe is installed at less than the required cover, the Contractor shall furnish and install insulation in accordance with Section 33 11 13.43, INSULATION FOR PIPELINES, or as required by the Engineer.

B. PIPE AND FITTINGS:

1. No defective pipe or fittings shall be laid or placed in the piping, and any piece discovered to be defective after having been laid or placed shall be removed and replaced by a sound and satisfactory piece.
2. Each pipe and fitting shall be cleared of all debris, dirt, etc., before being laid and shall be kept clean until accepted in the complete work.
3. Pipe and fittings shall be laid accurately to the lines and grades indicated on the drawings or as required. Care shall be taken to ensure good alignment both horizontally and vertically.
4. In buried pipelines, each pipe shall have firm bearing along its entire length.

5. Castings to be encased in masonry shall be accurately set, with the bolt holes, if any, carefully aligned.
6. Immediately prior to being set, castings shall be thoroughly cleaned of all rust, scale and other foreign material.
7. Fittings shall not be used to clear beneath or above an existing structure or pipeline unless approved by the Engineer. The water main shall be brought to a depth sufficient to clear the structure or pipeline without the use of bends.

C. TEMPORARY PLUGS:

At all times when pipe laying is not actually in progress, the open ends of pipe shall be closed by temporary watertight plugs or by other approved means. If water is in the trench when work is resumed, the plug shall not be removed until all danger of water entering the pipe has passed.

D. PUSH ON JOINTS:

1. Joining of push-on joint pipe shall conform to AWWA C600.
2. If effective sealing of the joint is not attained, the joint shall be disassembled, thoroughly cleaned, a new gasket inserted and joint reassembled.
3. Deflection of alignment at a joint shall not exceed the appropriate permissible deflection as specified in AWWA C600. The tables in AWWA C600 indicate the maximum permissible deflection for 18 and 20-foot pipe lengths. Maximum permissible deflections for other lengths shall be in proportion to such lengths.

E. MECHANICAL JOINTS:

1. Assembling of fittings with mechanical joint ends shall conform to AWWA C600.
2. If effective sealing of the joint is not attained at the maximum torque indicated in the above standard, the joint shall be disassembled and thoroughly cleaned, then reassembled. Bolts shall not be overstressed to tighten a leaking joint.
3. The deflection of alignment at a joint shall not exceed the appropriate permissible deflection as specified in the following table. These values indicate the maximum

permissible deflection for 18-foot lengths. Maximum permissible deflections for other lengths shall be in proportion to such lengths.

Pipe Deflection Allowances	
Maximum permissible deflection, inches	
<u>Diameter of Pipe (inches)</u>	<u>Mechanical-Joint</u>
6	27
8-12	20
16	13.5
20	11
24	9

F. RESTRAINED JOINTS:

1. Joining of restrained joint piping shall conform to the manufacturer's recommendations.
2. If effective sealing of the joint is not attained, the joint shall be disassembled, thoroughly cleaned, a new gasket inserted and joint reassembled.
3. Deflection of alignment at a joint shall not exceed the appropriate permissible deflection recommended by the manufacturer.
4. All restraining appurtenances (and tie rods) shall be coated with an approved bituminous paint after assembly. The completed joint shall be inspected and the paint repaired/touched-up as necessary.

G. SLEEVE-TYPE COUPLINGS:

1. Pipe ends shall be cleaned thoroughly prior to installation. After the bolts have been inserted and all nuts have been made up finger tight, diametrically opposite nuts shall be progressively and uniformly tightened all around the joint, preferable by use of a torque wrench of the appropriate size and torque for the bolts. The correct torque as indicated by a torque wrench shall not exceed 90 foot-lb. for joints up to 24-inches.

3.04 POLYETHYLENE ENCASEMENT:

- A. The pipe to be encased shall be thoroughly cleaned of all soil and debris prior to installation of the polyethylene encasement. No soil or debris shall be allowed to enter the encasement during or after its installation.

- B. Polyethylene encasement shall be installed using Method A as described in AWWA C105, with the encasement joints coincident with pipe joints. Adhesive tape shall be used to secure the encasement.
- C. Minimum overlap of polyethylene encasement shall be 24-inches, 12 inches on each side of pipe joints.
- D. If required, two layers of polyethylene encasement shall be installed. The first layer shall be completely installed on and secured to the length of pipe before the second layer is installed.
- E. Tears, cuts and other damage shall be repaired with a piece of polyethylene covering secured with adhesive tape, when approved by the Engineer. Otherwise, the damaged length of polyethylene shall be replaced at the Contractor's expense.
- F. Care shall be taken when backfilling to avoid damage to the polyethylene encasement.
- G. Service and fitting connections shall be made by making an x-shaped cut in the polyethylene and folding back the cut film. Immediately following completion of the connection, the film shall be secured to the connection with adhesive tape and the cut area repaired. Service connections shall be wrapped with polyethylene encasement for a minimum of 3 feet from the point of connection to the encased pipe.
- H. At the junctions between wrapped and unwrapped pipe the polyethylene encasement shall be extended a minimum of 3 feet beyond the end of the pipe scheduled to be encased and the ends of the encasement securely taped so that no soil can enter the encasement.

3.05 TESTING:

- A. Prior to the hydrostatic pressure test, the piping shall be thoroughly flushed clean of all dirt, dust, oil, grease and other foreign material. This work shall be done with care to avoid damage to linings and coatings. Flushing velocity shall be a minimum of 2.5 ft./sec.
- B. The installed pipe shall be pressure tested in accordance with AWWA Standard C600.
- C. HYDROSTATIC PRESSURE TEST:
 - 1. Unless otherwise approved, all pipelines shall be given a hydrostatic pressure test between line valves. The Contractor shall furnish and install suitable temporary testing plugs or caps; all necessary pressure pumps, pipe connections, meters, gates,

and other necessary equipment; and all labor required. The Owner or Engineer shall have the privilege of using its own gauges.

2. Subject to approval and provided that the tests are made within a reasonable time considering the progress of the project as a whole, and the need to put the section into service, the Contractor may make the tests when desired.
3. Pipelines intended for buried service shall be tested after backfill and compaction of the trench.
4. The section of pipe to be tested shall be filled with water of approved quality and all air shall be expelled from the pipe. The Contractor shall follow established procedures for filling the pipe and expelling trapped air to avoid exposing the piping system to water-hammer. If blowoffs are not available at high points for releasing air, the Contractor shall excavate as required and install the necessary taps. If the Contractor changes the grade of pipe installation, it will be responsible for locating the taps at the correct location in the system for testing. Taps shall be installed at the beginning and end of each disinfection run. After completion of the test, if so required by the Engineer, the Contractor shall remove corporations used for testing; plug the holes; and backfill, as necessary.
5. The section under test shall be maintained full of water at working pressure for a period of 24 hours prior to the hydrostatic pressure test being applied to stabilize the pipeline with respect to movement under pressure, water absorption by the lining, etc. The pipeline may require several cycles of pressurizing and bleeding trapped air prior to beginning the test.
6. When hydrants are in the pipeline test section, the hydrostatic test shall be made against the main valve in the hydrant. The hydrostatic test shall not be conducted against the branch valve.
7. The hydrostatic test shall consist of raising the water pressure within the test section to a pressure not less than 1.25 times the working pressure of the pipeline measured at the highest elevation along the test section and not less than 1.5 times the working pressure of the lowest elevation of the test section. The specified test pressure shall be corrected to the elevation of the test gauge.
8. The hydrostatic test shall be of at least a 2 hour duration. The test pressure shall not vary by more than +/- 5 psi for the duration of the test. Test pressure shall be maintained within this tolerance by adding makeup water through the pressure test pump into the pipeline test section.
9. The amount of makeup water (testing allowance) added to the test section shall be accurately measured by suitable methods and shall not exceed the maximum

allowable quantity of makeup water. No pipe installation will be accepted if the quantity of makeup water is greater than that determined by the following formula:

$$L = \frac{S D \sqrt{P}}{148,000}$$

Where:

L = makeup water, in gallons per hour

S = length of test section, in feet

D = nominal diameter of pipe, in inches

P = average test pressure, in psi (gauge)

10. If the section fails to pass the hydrostatic pressure test, the Contractor shall do everything necessary to locate, uncover, and repair or replace the defective pipe, fitting, or joint, all at its own expense and without extension of time for completion of the work. Additional tests and repairs shall be made until the section passes the specified hydrostatic test.

3.06 DISINFECTION AND FLUSHING:

- A. The Contractor shall disinfect the lines carrying potable water.
- B. The Contractor shall furnish all equipment and materials necessary to do the work of disinfecting and shall perform the work in accordance with the procedure outlined in AWWA C651 and all amendments thereto.
- C. In general, the procedure of disinfecting the main shall be to apply the chlorine through a tap in one end of the section and bleed it off through a tap at the other end.
- D. The applied dosage shall be such as to produce a chlorine concentration of not less than 10 mg/l after a contact time of not less than 24 hours.
- E. During the disinfection period, care shall be exercised to prevent contamination of water in existing mains.
- F. Any temporary connection to the mains or other facilities required to accomplish the disinfection of the mains shall be at the Contractor's expense.
- G. After treatment, the main shall be flushed with clean water until the residual chlorine concentration is less than 0.2 mg/l. The flushing rate shall be 3.0 ft/sec to achieve full scour of sand particles.

- H. Before disposing of the water used in disinfecting and flushing water mains the Contractor shall thoroughly neutralize it through the application of a reducing agent, as referenced in AWWA C651 and C655.
- I. Bacteriological sampling and testing shall be done in accordance with AWWA C651 (Option A – One sample taken after flushing is complete followed by another sample taken 16 hours after the first sample or Option B – Two samples taken 15 minutes apart after a 16 hour post flushing rest period) for each main and each branch. Sampling shall be accomplished with sterile bottles treated with sodium thiosulfate, as required by Standard Methods. No hose or fire hydrants shall be used in collection of samples. A corporation stop installed on the main, with a removable copper tube gooseneck assembly, is the recommended method.
- J. Bacteriological sampling and testing shall be conducted by a state certified laboratory certified for total and fecal coliform analyses of potable water. A signed original paper copy of the results of the disinfection, bacteriological sampling, and laboratory test results shall be submitted to the Engineer and Town Engineer prior to any new pipeline being put into service.
- K. Testing shall be done by a laboratory approved by the Engineer, in accordance with Standard Methods, and shall show the absence of coliform organisms.

END OF SECTION

SECTION 33 11 13.16

WATER SERVICE CONNECTIONS

PART 1 - GENERAL

1.01 WORK INCLUDED:

This section covers the furnishing and installation of new water service connections and the repair, replacement, and/or transfer of existing water service connections as shown on the drawings, as specified herein, and as required by the Engineer.

1.02 RELATED WORK:

- A. Section 32 12 00, ASPHALT PAVING
- B. Section 32 91 19, LOAMING AND SEEDING
- C. Section 33 11 13.13, DUCTILE IRON PIPE AND FITTINGS FOR WATER MAINS

1.03 REFERENCES:

- A. The following standards form a part of this specification:

ASTM International (ASTM)

ASTM	B88	Standard Specification for Seamless Copper Water Tube
ASTM	B584	Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM	D2737	Standard Specification for Polyethylene (PE) Plastic Tubing

American Water Works Association (AWWA)

AWWA	C800	Underground Service Line Valves and Fittings
AWWA	C651	Disinfecting Water Mains
AWWA	C901	Polyethylene (PE) Pressure Pipe and Tubing, 3/4-inch through 3-inch for Water Service

1.04 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 23 SUBMITTALS, SUBMIT THE FOLLOWING:

Manufacturer's literature of the materials of this section for review.

PART 2 - PRODUCTS

2.01 SERVICE PIPING:

- A. Piping for buried copper water services shall be continuous Type K annealed seamless copper water tubing conforming to ASTM B88. Tubing diameter shall be as indicated on the Drawings.
- B. Couplings, if required, for existing to new service pipe connections shall have compression connections on the inlet and compression connections on the outlet. Couplings shall be made of brass as specified in AWWA C800. All brass components that come into contact with potable water shall be made from either CDA/UNS Brass Alloys C89520 or C89833 and shall not contain more than twenty five hundredths of one percent (0.25% or less) total lead content by weight. The lead leach limit of the coupling shall be 5 parts per billion (ppb). Couplings shall be NSF/ANSI 61 Annex F and Annex G and NSF/ANSI 372 certified by an ANSI accredited organization and shall be stamped or embossed with a mark or name indicating that the product is manufactured from a low-lead alloy, as specified above.

2.02 CORPORATION STOPS:

- A. Corporations stops shall be made of brass as specified in AWWA C800. All brass components that come into contact with potable water shall be made from either CDA/UNS Brass Alloys C89520 or C89833 and shall not contain more than twenty five hundredths of one percent (0.25% or less) total lead content by weight. The lead leach limit of the corporation stops shall be 5 ppb. Corporation stops shall be NSF/ANSI 61 Annex F and Annex G and NSF/ANSI 372 certified by an ANSI accredited organization and shall be stamped or embossed with a mark or name indicating that the product is manufactured from a low-lead alloy, as specified above.
- B. The inlet shall have AWWA taper thread (CC) connections, and the outlet shall have compression connections.
- C. Tapping sleeves and valves shall be installed with all corporation stops larger than 2-inches in size (and with all corporation stops installed in PVC pipe). Taps for corporation stops 2 inches and smaller shall be direct taps with no saddle.
- D. Corporation stops shall be by Ford Meter Box Co., Inc., Wabash, IN; Red Hed RI, Lincoln, RI; Mueller Co., Decatur, IL; or approved equal.

2.03 CURB STOPS:

- A. Curb stops shall be of brass as specified in AWWA C800. All brass components that come into contact with potable water shall be made from either CDA/UNS Brass Alloys C89520 or C89833 and shall not contain more than twenty five hundredths of one percent (0.25% or less) total lead content by weight. The lead leach limit of the curb stops shall

be 5 ppb. Curb stops shall be NSF/ANSI 61 Annex F and Annex G and NSF/ANSI 372 certified by an ANSI accredited organization and shall be stamped or embossed with a mark or name indicating that the product is manufactured from a low-lead alloy, as specified above.

- B. Curb stops shall be Mueller (H-15209) or threaded Mueller (B-25209) or Ford, and the inlet and the outlet shall have compression connections, no drain, per the Needham Water Division.
- C. Curb stops shall be by Ford Meter Box Co., Inc., Wabash, IN; Mueller Co., Decatur, IL; or approved equal.

2.04 CURB BOXES:

- A. The cast iron box shall be the Bingham & Taylor eclipse style, per the Needham Water Division. The minimum inside diameter of the upper section shall be 1-1/2-inch for 3/4-inch and 1-inch curb stops and 2-inch for 1-1/2-inch and 2-inch curb stops. The curb box lid shall be Erie pattern.
- B. Boxes shall be equipped with 30-inch stationary, curved stainless steel extension rods with pinned connections to the curb stop.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Where new water mains are being installed and existing water services are to be transferred to the new main, the Contractor shall discontinue the existing water services by shutting down the corporation stop at the old water main, unless specifically otherwise required by the Engineer. The Contractor shall take special care to minimize the interruption of existing water service.
- B. The Contractor shall tap a new corporation stop, cut the existing service piping and connect the new service piping to the old service piping using an approved coupling at a point between the main and the existing curb stop and box.
- C. Where transfers are to be made and the existing curb stop and box cannot be utilized or a new curb stop and box is required, the Contractor shall connect the new service piping to the existing service piping using an approved coupling approximately 12-inches from the curb stop on the building side of the stop.
- D. Where transfers are being made and the existing service is of lead, galvanized steel, or iron, the service shall be replaced to the curb stop and box unless otherwise required. If required, the curb stop and box shall be replaced as specified above.
- E. Curb stops and boxes shall be set plumb, flush with the ground or paved surface, and centered with the box located directly over the stop. The box shall be set on a concrete

block or flat stone. Earth fill shall be carefully tamped around the boxes to a distance of 4 feet on all sides of the box or to the undisturbed face of the trench, if less than 4 feet.

- F. Curb stops shall be operational and accessible at all times during construction and warranty period. The Contractor shall verify the proper operation of all curb stops in the presence of the Engineer and/or Owner following completion of the project and prior to the acceptance of substantial completion.
- G. All services shall be installed at 5 feet 0 inches of cover unless otherwise required by the Engineer.
- H. Service connections shall be tested and disinfected in accordance with AWWA standards.

END OF SECTION

SECTION 33 11 13.43

INSULATION FOR PIPELINES

PART 1 - GENERAL

1.01 WORK INCLUDED:

This Section covers the furnishing of all material, accessories, labor, and equipment necessary to insulate the pipelines where shown/detailed on the Drawings, as indicated in the Division 33 specifications, or where so required by the Engineer.

1.02 RELATED WORK:

- A. Section 31 00 00, EARTHWORK
- B. Section 33 11 13.13, DUCTILE IRON PIPE AND FITTINGS FOR WATER MAINS

1.03 REFERENCES:

- A. The following standards form a part of this specification as referenced:

ASTM International (ASTM)

ASTM	C552	Specification for Cellular Glass Block and Pipe Thermal Insulation

1.04 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 23 SUBMITTALS, SUBMIT THE FOLLOWING:

- A. Manufacturer's literature of the materials of this section and installation instructions for the products being provided for the project.
- B. A sample of the insulation.

PART 2 - PRODUCTS

2.01 INSULATION: DIRECT BURIED PIPE

- A. Insulation for water pipes shall be installed in locations where five (5) feet of cover cannot be achieved over the top of the pipe. Insulation shall be cellular glass type. The insulation shall be a cellular glass product that is made specifically for thermal insulation of piping and is compatible with the piping material. Insulation shall be a minimum of 2-inches thick, unless otherwise shown on the Drawings.

- B. Insulation shall be composed of all glass sealed cells having no binders or fillers. The completed product shall be rigid and impermeable, with an ultimate compressive strength of at least 90 psi. The thermal conductivity of the cellular glass shall be no higher than 0.29 BTU-in./hr • ft² • °F @ 75°F and 0.28 BTU-in./hr • ft² • °F @ 50°F.
- C. The cellular glass insulation shall comply with all requirements of ASTM C552. The cellular glass shall be fabricated in half sections whenever possible.
- D. Bands for securing the insulation to the pipe shall be 0.5 inches wide by 0.020 inches thick made of stainless steel.
- E. The jacketing for the insulation shall be one of the following methods:
 - 1. A 125 mil (3mm) thick, heat sealed high polymer asphaltic membrane with an integral glass scrim and integral 1 mil (.02mm) aluminum foil and a thin Mylar film on the surface, equal to Pittwrap Jacketing as manufactured by Pittsburgh Corning or equal.
 - 2. Mastic - asphalt cutback mastic, equal to Pittcote 300 Finish, as manufactured by Pittsburgh Corning or equal.
 - 3. Reinforcing fabric - an open mesh polyester fabric with a 6 x 5.5 mesh/inch configuration, equal to PC Fabric 79, as manufactured by Pittsburgh Corning or equal.
- F. The insulation shall be "Foamglass" with jacketing as manufactured by Pittsburgh Corning Corporation, Pittsburgh, PA, or an approved equal. A minimum of 6" layer of fine sand shall surround the insulated pipe before rock free backfill is used in the trench.
- G. The Foamglass and jacketing shall be installed per the manufacturer instructions included in the approved shop drawings.
- H. Tees, valves, and bends shall be covered with form fitting factory made sections.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Cellular glass shall not be applied to the piping until the piping has been wiped clean and supported so that there is adequate space to apply the full thickness of insulation and the covering completely around the pipe. The Contractor must obtain the Engineer's approval before the installation begins.
- B. Cellular glass insulation and jacketing shall be applied in accordance with the manufacturer's installation procedures included in the approved shop drawings.
- C. There shall be at least three 0.50-inch wide stainless steel bands secured around each joint and these bands shall be placed not over 9 inches on center on straight sections of pipe.

- D. Tees, valves, and bends shall be covered with form fitting factory made sections.
- E. All testing of the piping system, such as hydrostatic, x-ray or other such testing, shall be accomplished prior to application of insulation.

END OF SECTION

SECTION 33 12 22

HYDRANTS AND VALVES FOR POTABLE WATER WORK

PART 1 - GENERAL

1.01 WORK INCLUDED:

- A. This Section covers the furnishing and installation of all outside hydrants, valves and appurtenances as indicated on the drawings and as specified herein.
- B. Pipe and couplings shall be specified under the appropriate pipe sections.

1.02 RELATED WORK:

- A. Section 31 00 00, EARTHWORK
- B. Section 33 11 13.13, DUCTILE IRON PIPE AND FITTINGS FOR WATER MAINS
- C. Section 33 11 13.34, CONNECTIONS TO EXISTING WATER MAINS

1.03 REFERENCES:

- A. The following standards form a part of this specification:

American Society for Testing and Materials (ASTM)

ASTM	A48	Gray Iron Castings
ASTM	A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM	A536	Ductile Iron Castings
ASTM	B62	Composition Bronze or Ounce Metal Castings
ASTM	D429	Test Method for Rubber Property Adhesion to Rigid Substrate.

American Water Works Association (AWWA)

AWWA	C500	Metal Seated Gate Valves For Water Supply Service
AWWA	C502	Dry-Barrel Fire Hydrants
AWWA	C504	Rubber-Seated Butterfly Valves
AWWA	C509	Resilient-Seated Gate Valves for Water Supply Service

AWWA C515 Reduced Wall, Resilient-Seated Gate Valves for Water Supply Service

AWWA C550 Protective Interior Coatings for Valves and Hydrants

Federal Specifications (FS)

FS TT-V-51F Varnish, Asphalt

1.04 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF THE GENERAL SPECIFICATIONS, SUBMIT THE FOLLOWING:

- A. Shop drawings shall be submitted for the hydrants, valves and appurtenances indicating type of joint, and lining and coating, etc., in accordance with the specifications.
- B. Shop drawings shall consist of manufacturer's scale drawings, cuts or catalogs including descriptive literature and complete characteristics and specifications, and code requirements.
- C. Refer to Paragraph 3.01.A for Affidavit of Compliance required to be submitted.

PART 2 - PRODUCTS

2.01 GENERAL:

- A. Valves shall open right (clockwise).
- B. Hydrants shall open right (clockwise).

2.02 HYDRANTS:

- A. The Contractor shall make all earth excavations, provide new fire hydrants including the 6 inch pipe hydrant connection, hydrant tee, and all appurtenant work, restraining joints, backfill, compact, dispose of excess materials and maintain the backfilled area in accordance with these specifications and as shown on the Drawings, or as directed by the Engineer.
- B. Hydrants shall be as manufactured by Mueller Company, Super Centurian 250 Model A-423, Kennedy Guardian K81D with drains/dry barrel, or approved equal, and shall be equipped with a National Standard operating nut and a National Standard nozzle thread. Hydrants shall be equipped 5-1/4 main valve opening three way, with two 2-1/2 hose nozzles and one 4-1/2 pumper nozzle and shall be designed for 78 inch burial, unless otherwise approved by the Engineer.
- C. Hydrants shall be of the compression type for 150 pound service having a minimum valve opening of 5 inches and shall have a break-away flange and 6 inch mechanical joint inlet.

Hydrants will be painted Yellow with a white bonnet. Hydrants will be outfitted with 5' fiberglass Red/White Reflective Hydrant marker with Red mini Flag attached by bolt on a flat Bracket with spring.

- D. Before ordering the hydrants, the Contractor shall submit the name of manufacturer and type of hydrants to the Engineer for approval. The hydrant shall be installed at least 24 inches and no more than 30 inches from the edge of the traveled way (gutter) and shall not obstruct any part of a sidewalk. The bottom of the hydrant shall be placed on a minimum eight (8) inch thick layer of compacted 3/4 inch to 1-1/2 inch crushed stone. The hydrant shall be set within 1/4 inch in 2 feet of plumb, and restraining joints shall be provided for both the hydrant tee and hydrant base. The six (6) inch valve shall be at least 24 inches from the edge of the traveled way.

2.03 HYDRANT PAINT:

- A. Hydrants shall be thoroughly cleaned and given two shop or field coats of paint in accordance with AWWA C502 and the instructions of the paint manufacturer. Paint color shall be confirmed with the Truro DPW prior to painting:
 - 1. Barrel - Safety yellow
 - 2. Bonnet - White
 - 3. Nozzle Caps - Safety yellow
- B. If the hydrants are delivered with the Owner's standard color, they shall be given one matching field coat of an alkyd gloss enamel. If the hydrants are not delivered with the Owner's standard color, they shall be given two coats of an alkyd gloss enamel, colors as indicated above.
- C. Hydrant paint shall be as manufactured by Sherwin-Williams, Cleveland, OH; Tnemec Company, Inc., Kansas City, MO; or Minnesota Mining and Manufacturing Co. (3M), St. Paul, MN; or approval equal.
- D. Alkyd gloss enamel shall be 801 DTM by Sherwin-Williams, 2H-Tneme by Tnemec; or approved equal. Reflective paint shall be Scotchlite #7211 by 3M.

2.04 RESILIENT SEAT GATE VALVES:

- A. Resilient seat, wedge type gate valves shall be manufactured to meet all applicable requirements of AWWA C509 or AWWA C515. All valves shall be bubble-tight at 200 psi water working pressure, tested in both directions.
- B. Valve bodies shall be of cast or ductile iron and shall have non-rising threaded bronze stems acting through a bronze stem nut. Opening nuts shall be 2-inches square and shall open as specified above. All buried valves shall have mechanical joint ends.
- C. Valve wedges shall be of ductile iron with resilient seating surfaces permanently bonded to the wedges in strict accordance with ASTM D429 or attached to the face of the wedges

with stainless steel screws. Each valve shall have a smooth, unobstructed water way free from sediment pockets.

- D. Valves shall have low friction, torque-reduction thrust bearings. All O-rings and gaskets shall be removable without taking the valves out of service.
- E. An NSF 61-approved epoxy coating, which is safe for potable water, shall be applied to exterior and interior valve surfaces.
- F. Valves for horizontal applications shall have Delrin wedge covers, and be specifically designed for horizontal installation.
- G. Resilient seat gate valves shall be as manufactured by Clow Valve Co., Oskaloosa, IA; Mueller Co., Decatur, IL; American Valve and Hydrant, Birmingham, AL; Waterous Co., S. St. Paul, MN; MH Valve, Anniston, AL; Kennedy Valve, Elmira, NY; or approved equal.
- H. Post indicating valve assemblies shall have a post and indicator as an integral part of the resilient seated gate valve assembly. The unit shall be provided with a detachable crank which OPENS the valve in a counterclockwise direction. Shafts shall be Type 304 stainless steel. Post indicators and valves shall be UL listed, FM approved. Post indicators and valves shall be as manufactured by Pratt, Clow or approved equal.

2.05 TAPPING SLEEVES AND VALVES:

- A. Tapping sleeves and valves shall consist of a split cast iron or ductile iron sleeve tee with mechanical joint ends on the main and a flange on the branch. Tapping-type gate valves shall have one flange and one mechanical joint end. The valves shall conform to the requirements hereinbefore specified for gate valves and shall be furnished with a 2-inch square operating nut. The Contractor shall be responsible for verifying the outside diameter of the pipe to be tapped.
- B. Oversized valves shall be provided as required to permit the use of full size cutters. Before backfilling, all exposed portions of bolts used to hold the two halves of the sleeve together shall be heavily coated with two coats of bituminous paint comparable to Inertol No. 66, Special Heavy. Sleeves shall be of cast iron furnished with rubber gaskets. Gaskets shall cover the entire area of flange surfaces.
- C. Tapping sleeves and valves shall be as manufactured by Clow Valve Co., Oskaloosa, IA; Mueller Co., Decatur, IL; American Valve and Hydrant, Birmingham, AL; MH Valve, Anniston, AL; Kennedy Valve, Elmira, NY; US Pipe, Chattanooga, TN; or approved equal.

2.06 BUTTERFLY VALVES:

- A. Buried butterfly valves shall be Class 150B, iron body, rubber seated, with mechanical joint ends. Butterfly valves shall conform to AWWA C504, except as otherwise specified

herein. Butterfly valves shall have valve seats designed to provide bubble-tight shutoff at 150 psi upstream and downstream.

- B. Butterfly valve designs utilizing continuous lining on the internal body surfaces and extending over the flanges, will NOT be acceptable. Valve disks shall seat at an angle of 90 degrees to the axis of the pipe.
- C. Valve seats shall be of molded natural rubber, BUNA-NM or EPDM. Rubber seats may be attached to the body or the disk. If the seat is attached to the disk, the seat ring on the body shall be of stainless steel. Bolts shall extend through the seat.
- D. Seats mounted on the disk shall be securely clamped to the disk. All clamps, retaining rings, and their fasteners shall be Series 300 stainless steel.
- E. The valve disk shall be of either ductile iron conforming to ASTM A536 or Type 304 stainless steel.
- F. The valve shaft shall be Type 300 stainless steel or carbon steel with stainless steel joints. The valve disk and shaft connection shall be by means of mechanically secured taper pins extending through the disk and shaft. Taper pins, lockwashers and nuts shall be 18-8 stainless steel. The shaft seals shall be designed for the use of standard chevron type packing or standard O-ring seals.
- G. The manual operation mechanism shall be firm fixed to the valve body. The operator shall be permanently lubricated, and totally enclosed with a cast iron case, and the nut for buried valves shall turn in the direction specified above to open. The operator for buried valves shall be suitable for submersion. The operator shall have adjustable threaded collars at each end of the stroke.
- H. Butterfly valves shall be as manufactured by MH Valve Company, Anniston, AL; Keystone Valves USA, Houston, TX; Henry Pratt Company, Aurora, IL; or approved equal and shall conform to the above specifications.

2.07 DAMPENED SWING CHECK VALVES:

- A. Provide swing check valves with weighted arm plus an externally mounted air cushion cylinder APCO Series 6000 as manufactured by Valve and Primer Corporation, Inc.; Golden-Anderson Figure 250-D as manufactured by GA Industries, Cranberry Township, PA, or approved equal.
- B. The dampened swing check valves shall be flanged with cast iron body, bronze seat ring and continuous stainless steel shaft connected to an external lever and weight and bronze air cushion cylinder.
- C. Valves shall be full ported and prevent reverse flow when the inlet pressure becomes less than the downstream pressure, and shall be tight seated.

- D. The disc shall be cast iron, utilizing a double clevis hinge connected to a ductile iron disc arm. The disc arm assembly shall be suspended from the stainless steel shaft.
- E. The air cushion cylinder shall be constructed of corrosion resistant material and the piston shall be totally enclosed within the cylinder (not open at one end). The cushion cylinder assembly shall be externally attached to the right side of the valve body looking downstream and be adjustable to cushion the closure of the valve. Cushioning shall be by air trapped in the cushion cylinder, which shall be fitted with a one-way adjustable control check valve to cushion disc contact to the seat at the shut-off point.

2.08 INSERTION VALVES:

- A. Insertion valves shall consist of a ductile iron or ASTM A-36 steel fusion bonded epoxy coated to 10-12 mils in accordance with AWWA C-213. The valves shall conform to the requirements herein specified for gate valves and shall be furnished with a 2-inch square operating nut. The contractor shall be responsible for verifying the outside diameter of the pipe where the valve will be inserted.
- B. Before backfilling, all exposed portions of bolts used to hold the two halves of the sleeve together shall be heavily coated with two coats of bituminous paint comparable to Inertol No. 66, Special Heavy. Sleeves shall be furnished with a rubber gasket that fits 360 degrees around the pipe at each end.
- C. Insertion valves shall be as manufactured by Hydra-Stop, Inc., Blue Island, IL; Romac Industries, Inc, Seattle, Washington; or approved equal.

2.09 WATER LINE STOPS:

- A. Water line stop fitting body shall consist of a ductile iron or ASTM A-36 steel fusion bonded epoxy coated to 10-12 mils in accordance with AWWA C-213. The fitting shall be full encirclement, pressure retention-type split tee. The outlet of the fitting shall have locking pins built in to retain the completion plug. The contractor shall be responsible for verifying the outside diameter of the pipe where the valve will be inserted.
- B. Before backfilling, all exposed portions of bolts used to hold the two halves of the sleeve together shall be heavily coated with two coats of bituminous paint comparable to Inertol No. 66, Special Heavy. Sleeves shall be furnished with a nitrile gasket that fits 360 degrees around the pipe at each end.
- C. The completion plug shall be machined from a stress relieved carbon steel weldment. It shall contain two (2) circumferential grooves: one to receive the locking devices from line stop flange and second to contain a compressible "O" ring to seal tight under pressure. The line stop fitting shall be closed with a blind flange. Facing and drilling of the blind flange shall be compatible with that of the line stop flange.
- D. The Contractor shall provide the materials, machines, and related equipment necessary to install the line stop into an existing piping system under full operating pressure without

interrupting service.

- E. Line stops shall be as manufactured by South Shore Pipeline, Hanover MA, John Hoadley & Sons, Inc. Rockland MA, Hydra-Stop, Inc., Blue Island, IL; IPSCO Paulsboro NJ; or approved equal.

2.10 VALVE BOXES AND EXTENSIONS:

- A. Valve boxes shall be manufactured in North America. The minimum outside diameter of the boxes shall be 5½-inches and the lengths shall be as necessary to suit the ground elevation and the depth of each valve operator, regardless of the depth of cover.
- B. When there is more than 6 feet of cover, valve operators shall have non-rising extension stems which raise the operating nut to a depth of approximately 4 feet below grade. The extension stem shall have a centering support ring at the upper end. The lower socket shall be tapped with a set screw into the valve nut to prevent the extension stem from lifting off the valve nut.
- C. Each valve shall be provided with a box which has a close fitting 7-1/4-inch diameter cover and is substantially dirt-tight. The top of the cover shall be flush with the top of the box rim. The word "WATER" shall be cast in the top of the cover.
- D. Valve boxes shall be of cast iron and of the adjustable sliding, heavy pattern type. They shall be so designed and constructed as to prevent direct transmission of traffic loads to the pipe or valve. The upper or sliding section of the box shall be provided with a flange on the top of the section (not on the bottom) having sufficient bearing area to prevent undue settlement. The lower section of the box shall be designed to enclose the operating nut and stuffing box of the valve and to rest on the backfill. The boxes shall be adjustable through at least 6 inches vertically without reduction of lap between sections to less than 8-inches.

2.11 POLYETHYLENE ENCASEMENT:

- A. The pipe shall be encased in polyethylene conforming to AWWA C105.

PART 3 - EXECUTION

3.01 AFFIDAVIT OF COMPLIANCE

- A. The manufacturer shall furnish as part of the shop drawing submittal the ENGINEER with an affidavit stating that valve(s), hydrants conform to the applicable requirements of the applicable AWWA Standard and the ENGINEER's specifications, and that all tests specified therein have been performed and all test requirements have been met and the test date.
- B. A copy of the Affidavit of Compliance shall be delivered to the construction site attached to each valve and/or hydrant furnished. The Affidavit shall be attached to the valve or

hydrant inside a waterproof pouch.

- C. Any valve or hydrant received without the required affidavit shall be removed from the project and replaced at no expense to the Owner.
- D. All materials shall be certified "NEW". No reconditioned or repaired materials are permitted. Any reconditioned or repaired materials furnished or installed shall be removed and replaced with new materials at no expense to the Owner.

3.02 INSTALLATION:

- A. All valves shall be carefully installed and supported in their respective positions free from distortion and strain. Care shall be taken to prevent damage or injury to the valves and appurtenances during handling and installation.
- B. All material shall be carefully inspected for defects in workmanship and all debris and foreign material cleaned out of valve openings and seats. All mechanisms shall be operated to check for proper functioning, and all nuts and bolts checked for tightness.
- C. Valves and other equipment that do not operate easily or are otherwise defective shall be repaired or replaced at the Contractor's expense.
- D. Hydrants shall be set plumb. Earth fill shall be carefully tamped around the hydrants to a distance of 4 feet on all sides of the hydrant, or to the undisturbed trench face, if less than 4 feet. Hydrants and connecting pipe shall have at least the same depth of cover as the distributing main. Hydrants shall be set upon a layer of stone or a slab of concrete not less than 4 inches thick and 15 inches square.
- E. Broken stone shall be placed around the base of the hydrant at the location of the drain hole, and backfill around the hydrant shall be thoroughly compacted to the grade line in a satisfactory manner. Hydrants shall have the interiors cleaned of all foreign matter before installation, and shall be inspected in both the open and closed positions.
- F. The body of the hydrant shall be of sufficient length to allow the hydrant to be set at the proper elevation, as shown on the drawings. Extensions shall be furnished and installed at the Contractor's expense, when required for greater depths.
- G. Valve boxes shall be set plumb, flush with the ground or paved surface, and centered directly over the operating nut of the valves. Earth fill shall be carefully tamped around the valve boxes to a distance of 4 feet on all sides of the boxes or to the undisturbed trench face, if less than 4 feet.
- H. Valves shall be operational and accessible at all times during construction and warranty period. The Contractor shall verify proper operation of all valves in the presence of the Engineer and/or Owner following completion of the project and prior to the acceptance of substantial completion.

- I. The Contractor shall furnish and install plain concrete for anchorage of hydrants. Concrete shall be of a mix not leaner than one part cement, 2 parts sand and 4 parts stone, and having a compressive strength of not less than 3,000 pounds per square inch at 28 days. Unless otherwise permitted by the Engineer, concrete shall be provided from an approved plant and any such concrete shall be subject to cylinder tests at the expense of the Contractor, if requested by the Engineer. The bowl of each hydrant shall be well braced with concrete backing against unexcavated earth at the end of the trench. The backing shall, unless otherwise directed by the Engineer, be so placed that the pipe and fitting joints will be accessible for repair.

3.03 POLYETHYLENE ENCASEMENT:

- A. The pipe, hydrants and valves to be encased shall be thoroughly cleaned of all soil and debris prior to installation of the polyethylene encasement. No soil or debris shall be allowed to enter the encasement during or after its installation.
- B. Polyethylene encasement shall be installed using Method A as described in AWWA C105, with the encasement joints coincident with pipe joints. Adhesive tape shall be used to secure the encasement.
- C. Minimum overlap of polyethylene encasement shall be 24-inches, 12-inches on each side of pipe joints.
- D. If required, two layers of polyethylene encasement shall be installed. The first layer shall be completely installed on and secured to the length of pipe before the second layer is installed.
- E. Tears, cuts and other damage shall be repaired with a piece of polyethylene covering secured with adhesive tape, when approved by the Engineer. Otherwise, the damaged length of polyethylene shall be replaced at the Contractor's expense.
- F. Care shall be taken when backfilling to avoid damage to the polyethylene encasement.

END OF SECTION

SECTION 33 31 13.16

POLYVINYL CHLORIDE GRAVITY PIPE AND FITTINGS (SDR-35)

PART 1 - GENERAL

1.01 WORK INCLUDED:

This section covers the furnishing and installation of Polyvinyl Chloride (PVC) pipe and fittings for gravity pipe systems, as indicated on the drawings and as specified herein.

1.02 RELATED WORK:

- A. Section 31 00 00, EARTHWORK
- B. Section 33 05 26.13, TRACER TAPE
- C. Section 33 39 13, PRECAST MANHOLES AND CATCH BASINS

1.03 REFERENCES:

- A. The following standards form a part of these specifications as referenced:

ASTM International (ASTM)

ASTM	D2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM	D3034	Specification for Type PSM Polyvinyl Chloride (PVC) Sewer Pipe and Fittings
ASTM	D3212	Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

1.04 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 23 SUBMITTALS, SUBMIT THE FOLLOWING:

Manufacturer's literature of the materials of this section.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. PVC nonpressure piping shall conform to ASTM D3034, all with SDR of 35 unless noted, and shall meet the specific requirements and exceptions to the aforementioned specifications that follow.
- B. PVC pipe shall be furnished in standard lengths.
- C. One pipe bell consisting of an integral wall section with a solid cross section rubber ring, factory assembled, shall be furnished with each standard, random and short length of pipe. Rubber rings shall be provided to the requirements of ASTM D3212.
- D. The rubber ring shall be retained within the bell of the pipe by a precision formed groove or recess designed to resist fishmouthing or creeping during assembly of joints.
- E. Spigot pipe ends shall be supplied with bevels from the manufacturer to ensure proper insertion. Each spigot end shall have an "assembly stripe" imprinted thereon to which the bell end of the mated pipe will extend upon proper jointing of the two pipes.
- F. PVC fittings shall be provided with bell and/or spigot configurations with rubber gasketed joints compatible with that of the pipe. Bend fittings with spigot ends shorter than the pipe recess bells will not be allowed. The shorter spigot end would not allow proper seating of the spigot in the mating bell and would permit undesired contact between the mating bell and the outside of the fitting bell.
- G. All pipe delivered to the job site shall be accompanied by independent testing laboratory reports certifying that the pipe and fittings conform to the above-mentioned specifications. In addition, the pipe shall be subject to thorough inspection and tests, the right being reserved for the Engineer to apply such of the tests specified as it may from time to time deem necessary.
- H. All cutting of pipe shall be done with a machine suitable for cutting PVC pipe. Cut ends shall be beveled when recommended by the pipe manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Except as modified herein, installation of the PVC pipe shall be in accordance with ASTM D2321.
- B. Each pipe length shall be inspected before being laid to verify that it is not cracked. Pipe shall be laid to conform to the lines and grades indicated on the drawings or given by the Engineer. Each pipe shall be so laid as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.
- C. The pipe shall be supported by compacted crushed stone as indicated in the associated trenching detail in the Drawings. Crushed stone shall be as specified under Section 31 00 00, EARTHWORK.

- D. The pipe shall not be driven down to grade by striking it with a shovel handle, timber, rammer, or other unyielding object. When each pipe has been properly bedded, enough of the backfill material shall be placed and compacted between the pipe and the sides of the trench to hold the pipe in correct alignment.
- E. Before a joint is made, the pipe shall be checked to assure that a close joint with the next adjoining pipe has been maintained and that inverts are matched and conform to the required line and grade.
- F. For pipe placed on crushed stone, immediately after the joint is made, the jointing area shall be filled with suitable materials so placed and compacted that the ends of either pipe will not settle under backfill load.
- G. No pipe or fitting shall be permanently supported on saddles, blocking, or stones.
- H. Branches and fittings shall be laid by the Contractor as indicated on the drawings, and/or as required by the Engineer. Open ends of pipe and branches shall be closed with PVC caps secured in place with premolded gasket joints or as required by the Engineer.
- I. All pipe joints shall be made as nearly watertight as practicable. There shall be no visible leakage at the joints and there shall be no sand, silt, clay, or soil of any description entering the pipeline at the joints. Where there is evidence of water or soil entering the pipeline, connecting pipes, or structures, the defects shall be repaired to the satisfaction of the Engineer.
- J. If applicable, the Contractor shall build a tight bulkhead in the pipeline where new work enters an existing sewer. This bulkhead shall remain in place until the Engineer authorizes its removal.
- K. Care shall be taken to prevent earth, water, and other materials from entering the pipe, and when pipe laying operations are suspended, the Contractor shall maintain a suitable stopper in the end of the pipe and also at openings for manholes.

3.02 QUALITY CONTROL

A. LEAKAGE TESTING:

1. On completion of a section of sewer, including building connections installed to the property line, the Contractor shall install suitable bulkheads as required, dewater and test the sewer for leakage.
2. Unless otherwise approved, the section shall be tested using low pressure air test procedures. If circumstances permit, the Engineer may allow testing by infiltration or exfiltration in lieu of air testing.
3. The air test procedures shall conform to the Uni-Bell Recommended Practice for Low Pressure Air Testing of Installed Sewer Pipe, UNI-B-6. The starting air pressure for the test shall be 4 psig (greater than the average groundwater back pressure of any groundwater above the pipe, but not greater than 9.0 psig). The minimum duration

permitted for the prescribed low pressure air exfiltration pressure drop between two consecutive manholes shall not be less than provided in Table I or Table II of UNI-B-6. The two tables are reproduced on the following pages.

4. Using the air pressure test, if there has been no leakage (zero psig drop) after one hour of testing, the section undergoing test shall have passed.
5. If either infiltration or exfiltration testing is permitted by the Engineer, the test shall be conducted for at least 24 hours. The amount of infiltration or exfiltration shall not exceed 100 gallons per inch-diameter per mile of sewer per 24 hours.
6. The infiltration test measures leakage into a section of sewer and may be used only where the groundwater level is one foot or more above the crown of the section of sewer pipe at its upper end and at least one foot above the top of building connections and chimneys. For making the infiltration tests, underdrains, if used, shall be plugged and other groundwater drainage shall be stopped to permit the groundwater to return to its normal level insofar as practicable. Allowances shall be made for water that may enter the sewer through pipe connections and inlets during the infiltration test.
7. Where the groundwater level is less than 1 foot above the top of the pipe at its upper end, the exfiltration test may be used. The sewers shall be subjected to an internal pressure by plugging the pipe at the lower end and then filling the pipelines and manholes with clean water to a height of 2 feet above the highest point in the system to be tested, including main pipeline, service connections and chimneys. When slopes between manholes are steep, the Contractor shall insure that this test can be accomplished without danger of forcing stoppers from wye or tee branches.
8. The rate of exfiltration from the sewers shall be determined by measuring the amount of water required to maintain the water level at the elevation established at the beginning of the test.
9. The Contractor shall construct such weirs or other means of measurements as may be required, shall furnish water and shall do all necessary pumping to enable the test to be properly made.
10. The Contractor shall be responsible for the satisfactory watertightness of the entire section of sewer. Should the sections under test fail to meet the requirements, the Contractor shall do all work of locating and repairing leaks and retesting as the Engineer may require without additional compensation. A plan of the method of repairing any leaks that are found shall be submitted to the Engineer for review.

B. PIPE DEFLECTION MEASUREMENT:

1. In accordance with ASTM D3034, no less than 30 days after completion of the PVC sewer pipe installation, the Contractor shall test the pipeline for deflection using a "go/no-go" deflection mandrel having a minimum of nine evenly spaced arms or prongs.

The "go/no-go" gauge shall be hand pulled through all sections of the pipeline by the Contractor. The Contractor shall submit drawings of the "go/no-go" gauge to the Engineer for approval prior to testing. Complete dimensions of the gauge for each diameter of pipe to be tested shall be in accordance with ASTM D3034.

2. Any section of pipe found to exceed 7.5 percent deflection shall be deemed a failed pipe and shall be excavated and replaced by the Contractor at its own expense.

TABLE I

SPECIFICATION TIME REQUIRED FOR A 1.0 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q=0.0015

Pipe Diameter (in)	Minimum Time (min:sec)	Length for Min. Time (ft)	Length for Longer Length (sec)	Specification time for length (L) shown (min:sec)							
				<u>100 ft</u>	<u>150 ft</u>	<u>200 ft</u>	<u>250 ft</u>	<u>300 ft</u>	<u>350 ft</u>	<u>400 ft</u>	<u>450 ft</u>
4	3:46	597	.380 L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6	5:40	398	.854 L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.52 L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374 L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	199	3.418 L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	159	5:342 L	14:10	14:10	17:48	22:15	26:42	31:09	31:09	35:36
18	17:00	133	7.692 L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	114	10.470 L	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24	22:40	99	13.674 L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33
27	25:30	88	17.306 L	28:51	43:16	57:41	72:07	86:32	100:57	115:22	129:48
30	28:20	80	21.366 L	35:37	53:25	71:13	89:02	106:50	124:38	142:26	160:15
33	31:10	72	25.852 L	43:05	64:38	86:10	107:43	129:16	150:43	172:21	193:53
36	34:00	66	30.768 L	51:17	76:55	102:34	128:12	153:50	179:29	205:07	230:46

TABLE II
SPECIFICATION TIME REQUIRED FOR A 0.5 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q=0.0015

Pipe Diameter (in)	Minimum Time (min:sec)	Length for Min. Time (ft)	Length for Longer Length (sec)	Specification time for length (L) shown (min:sec)							
				<u>100 ft</u>	<u>150 ft</u>	<u>200 ft</u>	<u>250 ft</u>	<u>300 ft</u>	<u>350 ft</u>	<u>400 ft</u>	<u>450 ft</u>
4	1:53	597	.190 L	1:53	1:53	1:53	1:53	1:53	1:53	1:53	1:53
6	2:50	398	.427 L	2:50	2:50	2:50	2:50	2:50	2:50	2:51	3:12
8	3:47	298	.760 L	3:47	3:47	3:47	3:47	3:48	4:26	5:04	5:42
10	4:43	239	1.187 L	4:43	4:43	4:43	4:57	5:56	6:55	7:54	8:54
12	5:40	199	1.709 L	5:40	5:40	5:42	7:08	8:33	9:58	11:24	12:50
15	7:05	159	2.671 L	7:05	7:05	8:54	11:08	13:21	15:35	17:48	20:02
18	8:30	133	3.846 L	8:30	9:37	12:49	16:01	19:14	26:26	25:38	28:51
21	9:55	114	5.235 L	9:55	13	17:27	21:49	26:11	30:32	34:54	39:16
24	11:20	99	6.837 L	11:24	17:57	22:48	28:30	34:11	39:53	45:35	51:17
27	12:45	88	8.653 L	14:25	21:38	28:51	36:04	43:16	50:30	57:42	46:54
30	14:10	80	10:683 L	17:48	26:43	35:37	44:31	53:25	62:19	71:13	80:07
33	15:35	72	12:926 L	21:33	32:19	43:56	53:25	64:28	75:24	86:10	96:57
36	17:00	66	15:384 L	25:39	38:28	51:17	64:06	76:55	89:44	102:34	115:23

END OF SECTION

SECTION 33 31 13.46

CONNECTIONS TO EXISTING STRUCTURES

PART 1 - GENERAL

1.01 WORK INCLUDED:

The Contractor shall furnish materials, tools, labor and equipment to cut suitable openings into the existing sewer manholes, make connections to existing sewers and all other work necessary to direct the existing sewage flow as indicated on the drawings and as herein specified.

1.02 RELATED WORK:

Section 33 39 13, PRECAST MANHOLES AND CATCH BASINS

1.03 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF THE GENERAL SPECIFICATIONS, SUBMIT THE FOLLOWING:

Prior to start of work, submit details of the methods proposed for doing the work and for maintaining the sewage flow as herein specified.

PART 2 - PRODUCTS - NOT APPLICABLE

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. The Contractor shall provide temporary plugs or provide other suitable means for maintaining the new sewer free of sewage flow until such time as it can be inspected and tested for leakage.
- B. Connections to the new sewer shall be made when required by the Engineer and only after the new pipeline has been inspected and has successfully passed the leakage test.
- C. The Contractor shall modify each existing structure for installation of the necessary piping, but in so doing shall confine the cutting to the smallest amount possible consistent with the work to be done.
- D. All new piping connected to existing structures shall be encased in concrete in a manner satisfactory to the Engineer.
- E. All work shall be done with the proper tools and by careful workmen competent to do work.

- F. The Contractor shall cut, reshape and fill the existing manhole tables and plug existing outlets as indicated on the drawings and as required by the Engineer, to accommodate the new connections. Reshaped manhole invert channels shall be smoothly shaped to permit the flow of sewage. Manhole invert channels shall be reconstructed as specified under Section 33 39 13, PRECAST MANHOLES AND CATCH BASINS.

END OF SECTION

SECTION 33 39 13

PRECAST MANHOLES AND CATCH BASINS

PART 1 - GENERAL

1.01 WORK INCLUDED:

This Section covers all precast manholes and catch basins complete, including, but not limited to, bases, walls, cones, mortar, inverts, frames and covers.

1.02 RELATED WORK:

- A. Section 31 00 00, EARTHWORK
- B. Section 32 12 00, ASPHALT PAVING
- C. Section 03 05 00, FIELD CONCRETE

1.03 SYSTEM DESCRIPTION:

- A. Precast sections shall conform in shape, size, dimensions, materials, and other respects to the details indicated on the Drawings or as required by the Engineer.
- B. All manholes and catch basins shall have concrete bases. Concrete bases shall be precast unless otherwise specified. Invert channels, if detailed, shall be formed of brick and mortar upon the base.
- C. Catch basins shall have a 4-foot deep sump and a hood.
- D. Riser and cone sections shall be precast concrete.

1.04 REFERENCES:

- A. The following standards form a part of this specification as referenced:

ASTM International (ASTM)

ASTM A48	Standard Specification for Gray Iron Castings
ASTM C32	Standard Specification for Sewer and Manhole Brick (Made From Clay or Shale)
ASTM C144	Standard Specification for Aggregate for Masonry Mortar
ASTM C207	Standard Specification for Hydrated Lime for Masonry Purposes
ASTM C478	Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C923	Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
ASTM C990	Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C1244	Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill

Occupational Safety and Health Administration

OSHA 29 CFR 1910.27	Fall Prevention Protection

1.05 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 23 SUBMITTALS, SUBMIT THE FOLLOWING:

- A. Manufacturer's literature of the materials of this section.
- B. Test reports as required by the Engineer.

PART 2 - PRODUCTS

2.01 PRECAST CONCRETE SECTIONS:

- A. All precast concrete sections shall conform to ASTM C478 with the following exceptions and additional requirements:

1. The wall thickness of precast sections shall be as designated on the drawings, meeting the following minimum requirements:

<u>Section Diameter (Inches)</u>	<u>Minimum Wall Thickness (Inches)</u>
48	5
60	6
72	7
84	8

2. Type II cement shall be used except as otherwise approved.
 3. Sections shall be steam cured and shall not be shipped until at least five days after having been cast.
 4. Minimum compressive strength of concrete shall be 4000 psi at 28 days.
 5. No more than two lift holes may be cast or drilled in each section.
 6. The date of manufacture and the name or trademark of the manufacturer shall be clearly marked on the inside of each precast section.
 7. Acceptance of the sections will be on the basis of material tests and inspection of the completed product.
 8. Circumferential steel reinforcement in walls and bases shall be a minimum of 0.12 sq. in./lin. ft. for 4-foot diameter sections and 0.15 sq. in./lin. ft. for 5- and 6-foot diameter sections. Reinforcing shall extend into tongue and groove.
- B. Conical reducing sections shall have a wall thickness not less than 5-inches at the bottom and wall thickness of 8-inches at the top. Conical sections shall taper from a minimum of 48-inches diameter to 24 or 30-inches diameter at the top, as shown on the drawings.
- C. Except where insufficient depth of cover dictates the use of a shorter base, bases shall be a minimum of 4 feet in height.
- D. Slab top sections and flat riser sections (Grade Rings) shall conform to the contract drawings, with particular attention focused upon the reinforcing steel and be designed to meet or exceed an HS-20 Loading requirement.
- E. The tops of the bases shall be suitably shaped by means of accurate ring forms to receive the riser sections.

- F. Precast sections shall be manufactured to contain wall openings of the minimum size to receive the ends of the pipes, such openings being accurately set to conform with line and grade of the sewer or drain. Subsequent cutting or tampering in the field, for the purpose of creating new openings or altering existing openings, will not be permitted except as required by the Engineer. Flexible rubber boots or non-shrink grout shall be installed at pipe openings in accordance with the Drawings to create a seal at the pipe openings.
- G. The exterior surfaces of all precast manhole bases, walls, and cones shall be given a minimum of one shop coat of bituminous dampproofing.
- H. The Engineer reserves the right to reject any unsatisfactory precast section and the rejected unit shall be tagged and removed from the job site immediately.
- I. The Engineer may also require the testing of concrete sections as outlined under Physical Requirements in ASTM C478 with the Contractor bearing all testing costs.

2.02 BRICK MATERIALS:

- A. Brick shall be sound, hard, and uniformly burned brick, regular and uniform in shape and size, of compact texture, and satisfactory to the Engineer. Bricks shall comply with ASTM C32, for Grade SS, hard brick, except that the mean of five tests for absorption shall not exceed 8 percent by weight.
- B. Rejected brick shall be immediately removed from the work and brick satisfactory to the Engineer substituted.
- C. Mortar shall be composed of portland cement, hydrated lime, and sand in which the volume of sand shall not exceed three times the sum of the volumes of cement and lime. The proportions of cement and lime shall be as required by the Engineer and may vary from 1:1/4 for dense hard-burned brick to 1:3/4 for softer brick. In general, mortar for Grade SS Brick shall be mixed in the volume proportions of 1:1/2:4-1/2; portland cement to hydrated lime to sand.
- D. Cement shall be Type II portland cement as specified for concrete masonry.
- E. Hydrated lime shall be Type S conforming to ASTM C207.
- F. The sand shall comply with ASTM C144 specifications for "Fine Aggregate," except that all of the sand shall pass a No. 8 sieve.

2.03 FRAMES, GRATES, COVERS AND STEPS:

- A. Castings shall be of good quality, strong, tough, even-grained cast iron, smooth, free from scale, lumps, blisters, sandholes, and defects of every nature which would render them unfit for the service for which they are intended. Contact surfaces of covers and frame seats shall be machined to prevent rocking of covers.

- B. All castings shall be thoroughly cleaned and may be subject to a careful hammer inspection at the Engineer's discretion.
- C. Castings shall be ASTM A48 Class 30B or better.
- D. The surface of the manhole covers shall have a diamond pattern with the cast words "WATER," "DRAIN" or "SEWER," whichever is appropriate.
- E. Manhole frames with 32-inch covers for 30-inch openings shall be 500 pounds minimum by EJ, No. V-1419; Neenah Foundry Co. 1740B or approved equal.
- F. Watertight type manhole frames with 32-inch diameter covers (bolted and gasketed) shall be EJ, No. 2006APT 2008ZPT; Neenah Foundry Co. 1916-H or approved equal.
- G. Manhole frames with 26-inch covers for 24-inch openings shall be 475 pounds minimum by EJ No. 2110 (formerly LK110A); Neenah Foundry Co. R1720 or approved equal.
- H. Watertight type manhole frames with 26-inch diameter covers (bolted and gasketed) shall be EJ No. 1268; Neenah Foundry Co. 1916-F or approved equal.
- I. Frostproof manhole frames, with 30-inch diameter covers and inner lids, shall be 1755 series by Neenah Foundry Co., Neenah, WI; 2006A1 2009Z by EJ, Brockton, MA or approved equal.
- J. 2-inch thick polystyrene insulation shall be firmly adhered to all frostproof inner lids.
- K. Catch basin frames and 23-7/8-inch square grates with 2-inch square openings shall be 8-inches in height minimum. They shall be Neenah Foundry Co. No. 3588; EJ 5548Z 5520M; or approved equal.
- L. Catch basin frames with bar grate openings and 23-7/8-inch square grates shall be 8-inches in height minimum. Bar grates shall not be used in areas where bicycle traffic could be present. They shall be Neenah Foundry Co. No. 3589; EJ 5521Z 5520M3 BIKE GR LK121; or approved equal.
- M. Catch basin frames with cascade grate openings and 23-7/8-inch square grates shall be 8-inches in height minimum. They shall be Neenah No. 3589; EJ 5548Z 5520M; or approved equal.
- N. Catch basin frames set against curbing shall have three flanges only.
- O. Manhole steps, if proposed, shall conform to ASTM C478 requirements and shall be fabricated of either extruded aluminum or steel reinforced plastic. Steps shall be uniformly spaced at a maximum of 12-inches unless otherwise shown on the drawings.

2.04 SEWER MANHOLE ACCESSORIES:

- A. Gasket materials shall be top grade (100% solids, vulcanized) butyl rubber and shall meet or exceed ASTM C990.
- B. Couplings at the manhole-pipe interface shall be made with a rubber seal system (with or without stainless steel straps) meeting the requirements of ASTM C923 and recommended for this type of connection.
- C. Stubs installed as specified and indicated on the drawings shall be short pieces of the same class pipe as that entering the manhole and shall have either stoppers or end caps as shown on the drawings. Stoppers or end caps shall be especially designed for that application.

2.05 MANHOLE FALL PREVENTION SYSTEMS:

- A. Where manholes exceed 20 vertical feet from the proposed rim elevation to the invert, manholes shall be provided with a fall prevention system. Fall prevention systems shall be in accordance with OSHA requirement 29 CFR 1910.27 and as described herein and as indicated on the contract drawings.
- B. Carrier rail assembly shall be 1-5/16-inch O.D. by 1-inch ID Type 6061-T6 aluminum notched; 0.875-inches by 0.875-inches by 5/32-inch at 6-inch centers; tapped 3/8-inch at 9-inch centers opposite notches.
- C. Manhole rung clamp assembly shall be constructed from 6061-T6 aluminum 11-inches long by 1.25-inches wide with 2 slots 7/16-inch by 1.25-inches at 9-inch centers and serrated on one side.
- D. Safety locking mechanism shall be cast of manganese bronze with stainless steel springs and drop forged links and snap-locking pawl shall be minimum tensile strength of 110,000 psi. Roller bearing shall be killian type. Stainless steel springs shall comply with ASTM A313 and A580.
- E. Safety harness shall be adjustable to fit waists 30-inch to 48-inch. The belt shall be nylon web equipped with 3 stainless steel 'D' rings.
- F. Fall prevention systems shall be manufactured by DBI/SALA, Safe Approach or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. PRECAST SECTIONS:

1. Precast bases shall be supported on a compacted level foundation of crushed stone, as specified in Section 31 00 00 EARTHWORK, at least 6-inches thick, but shall vary to the depth necessary to reach sound undisturbed earth.
2. Precast reinforced concrete sections shall be set vertical and with sections in true alignment.
3. Butyl rubber joint sealant shall be installed between each concrete section. Catch basin sections do not require joint sealant if so indicated on the drawings.
4. All holes in sections used for handling the sections shall be thoroughly plugged with mortar. Mortar shall be one part cement to 1-1/2 parts sand, mixed slightly damp to the touch (just short of "balling"), hammered into the holes until it is dense, and an excess of paste appears on the surface, and then finished smooth and flush with the adjoining surfaces.

B. BRICK WORK:

1. Bricks shall be moistened by suitable means, as required by the Engineer, until they are neither so dry as to absorb water from the mortar nor so wet as to be slippery when laid.
2. Each brick shall be laid as a header in a full bed and joint of mortar without requiring subsequent grouting, flushing or filling, and shall be thoroughly bonded as directed.
3. The brick inverts for sewer manholes shall conform accurately to the size of the adjoining pipes. Side inverts shall be curved, and main inverts (where direction changes) shall be laid out in smooth curves of the longest possible radius which is tangent to the centerlines of adjoining pipe.

C. CASTINGS:

1. Cast iron frames, grates and covers shall be as specified. The frames and covers shall be set by the Contractor to conform accurately to the grade of the finished pavement, existing ground surface, or as indicated on the drawings. Frames shall be adjusted to meet the street surface.
2. Cast iron manhole frames and covers not located in paved areas shall be either set 6-inches above finished grade, at a height as required by the Engineer, or as indicated on the drawings. The top of the cone shall be built up with a minimum of 1 course and a maximum of 5 courses of brick and mortar used as headers for adjustment to final grade.
3. Frames shall be set concentric with the top of the concrete section and in a full bed of mortar so that the space between the top of the concrete section or brick headers

and the bottom flange of the frame shall be completely filled and made watertight. A thick ring of mortar extending to the outer edge of the concrete shall be placed all around the bottom flange. The mortar shall be smoothly finished to be flush with the top of the flange and have a slight slope to shed water away from the frame.

4. Covers and/or grates shall be left in place in the frames, for safety reasons, except while work is being performed.

D. ACCESSORIES:

1. Accessories shall be installed in accordance with the manufacturer's instructions.
2. Stubs shall be set accurately to the dimensions indicated on the drawings. Stubs shall be sealed with suitable watertight plugs.

E. MANHOLE FALL PREVENTION SYSTEM:

Carrier rail shall extend from the manhole invert shelf to within 18-inches of finish grade. The rail and manhole rung clamp assembly shall be rigidly connected utilizing 3/8-inch stainless steel bolts. Assembly shall be clamped to manhole steps at 2-foot centers or as recommended by the manufacturer.

3.02 LEAKAGE TESTS:

- A. Leakage tests shall be made by the Contractor and observed by the Engineer on each manhole. The test shall be by vacuum or by water exfiltration as described below:

B. VACUUM TEST:

1. The vacuum test shall be conducted in accordance with ASTM C1244. Test results will be judged by the length of time it takes for the applied vacuum to drop from 10 inches of mercury to 9 inches. If the time is less than that listed in Table 1 of ASTM C1244, the manhole will have failed the test. Test times from Table 1 are excerpted below.

TABLE 1

Minimum Test Times for Various Manhole Diameters

Depth (Feet)	Diameter (Inches)		
	48	60	72
	Times (Seconds)		
0-12	30	39	49
12-16	40	52	67
16-20	50	65	81

20-24	59	78	97
26-30	74	98	121

2. If the manhole fails the initial test, the Contractor shall locate the leaks and make proper repairs. Leaks may be filled with a wet slurry of accepted quick setting material. If the manhole should again fail the vacuum test, additional repairs shall be made, and the manhole water tested as specified below.

C. WATER EXFILTRATION TEST:

1. After the manhole has been assembled in place, all lifting holes shall be filled and pointed with an approved non-shrinking mortar. All pipes and other openings into the manhole shall be suitably plugged and the plugs braced to prevent blow out. The test shall be made prior to placing the shelf and invert. If the groundwater table has been allowed to rise above the bottom of the manhole, it shall be lowered for the duration of the test.
2. The manhole shall be filled with water to the top of the cone section. If the excavation has not been backfilled and observation indicates no visible leakage, that is, no water visibly moving down the surface of the manhole, the manhole may be considered to be satisfactorily water-tight. If the test, as described above, is unsatisfactory as determined by the Engineer or if the manhole excavation has been backfilled, the test shall be continued. A period of time may be permitted if the Contractor so wishes, to allow for absorption by the manhole. At the end of this period, the manhole shall be refilled to the top of the cone, if necessary, and a measuring time of at least 8 hours begun. At the end of the test period, the manhole shall be refilled to the top of the cone, measuring the volume of water added. This amount shall be extrapolated to a 24-hour loss rate and the leakage determined on the basis of depth. The leakage for each manhole shall not exceed one gallon per vertical foot for a 24-hour period. If the manhole fails this requirement, but the leakage does not exceed 3 gallons per vertical foot per day, repairs by approved methods may be made as required by the Engineer to bring the leakage within the allowable rate of one gallon per foot per day. Leakage due to a defective section or joint or exceeding the 3 gallon per vertical foot per day, shall be cause for rejection of the manhole. It shall be the Contractor's responsibility to uncover the rejected manhole as necessary and to disassemble, reconstruct or replace it as required by the Engineer. The manhole shall then be retested and, if satisfactory, interior joints shall be filled and pointed.
3. No adjustment in the leakage allowance will be made for unknown causes such as leaking plugs, absorption, etc. It shall be assumed that all loss of water during the test is a result of leaks through joints or through the concrete. Furthermore, the Contractor shall take any steps necessary to assure the Engineer that the water table is below the bottom of the manhole throughout the test.

4. If the groundwater table is above the highest joint in the manhole, and there is no leakage into the manhole, as determined by the Engineer, such a test can serve to evaluate water-tightness of the manhole. However, if the Engineer is not satisfied with the results, the Contractor shall lower the water table and carry out the test as described hereinbefore.

3.03 CLEANING:

All new manholes shall be thoroughly cleaned of all silt, debris and foreign matter of any kind, prior to final inspection.

END OF SECTION

SECTION 33 41 13.22

CORRUGATED POLYETHYLENE [HDPE] DRAINAGE PIPE

PART 1 – GENERAL

1.01 WORK INCLUDED:

- A. This section includes furnishing all materials, labor and equipment and installing corrugated high density polyethylene [HDPE] drainage pipe and fittings as shown on the drawings and as specified herein.

1.02 RELATED WORK:

- A. Section 31 00 00 – EARTHWORK
- B. Section 31 50 00 – SUPPORT OF EXCAVATION

1.03 REFERENCES:

- A. The following standards form a part of this specification, as referenced:

ASTM International (ASTM)

ASTM D2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications
ASTM F405	Standard Specification for 3 through 24 in. Corrugated Polyethylene Pipe and Fittings

American Association Of State Highway and Transportation Officials

AASHTO M294	Standard Specification for Corrugated Polyethylene Pipe (12- to 60-in. Diameter)

1.04 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 23 SUBMITTALS, SUBMIT THE FOLLOWING:

- A. Manufacturer's literature on the materials of this Section.
- B. Manufacturer's certification that the product was manufactured, tested, and supplied in accordance with this specification.

1.05 DELIVERY, STORAGE AND HANDLING:

- A. Pipe shall be packaged to withstand shipment without damage and handled carefully on the jobsite. Pipe shall be stored so that it is not exposed to sunlight.

PART 2 – PRODUCTS:

2.01 MATERIALS:

- A. This Section applies to corrugated polyethylene pipe with an integrally formed smooth interior.
- B. The nominal size for the pipe and fittings is based on the nominal inside diameter of the pipe.
- C. The pipe and fittings shall be free of foreign inclusions and visible defects. Fittings may be either molded or fabricated. Fittings supplied by manufacturers other than the supplier of the pipe shall not be permitted without the approval of the Engineer. The ends of the pipe shall be cut squarely and cleanly so as not to adversely affect joining.

2.02 MANUFACTURERS:

- A. Pipe and fittings shall be manufactured by Ipex, Inc.; Plexco, Division of Chevron Phillips Chemical Co.; JM Eagle; Advanced Drainage Systems (ADS) or approved equal.

PART 3 – EXECUTION

3.01 INSTALLATION:

- A. Pipe interiors, fitting interiors, and joint surfaces shall be thoroughly cleaned before installation. Pipes and fittings shall be maintained clean.
- B. Pipes shall be installed in the locations and to the required lines and grades shown on the drawings and provided in these Specifications, using an approved method of control.
- C. Excavations shall be maintained free of water during the progress of the Work. No pipes shall be laid in water, nor shall there be any joints made up in water.
- D. If any defective pipe is discovered after being placed, removal and replacement with sound pipe will be required at no additional cost to the Owner.

END OF SECTION

SECTION 33 44 26

UNDERGROUND STORMWATER CHAMBER SYSTEM

PART 1 - GENERAL

1.01 WORK INCLUDED:

- A. The Contractor shall furnish all labor, materials, equipment and incidentals required and install the underground stormwater chamber system and appurtenances in accordance with the Drawings and these specifications.

1.02 RELATED WORK:

- A. Section 31 00 00, EARTHWORK

1.03 QUALITY CONTROL INSPECTION:

- A. The quality of materials, the process of manufacture, and the finished sections shall be subject to inspection by the Engineer. Such inspection may be made at the place of manufacture, or on the work site after delivery, or at both places, and the sections shall be subject to rejection at any time if material conditions fail to meet any of the specification requirements, even though sample sections may have been accepted as satisfactory at the place of manufacture. Sections rejected after delivery to the site shall be marked for identification and shall be removed from the site at once. All sections which have been damaged beyond repair during delivery will be rejected and, if already installed, shall be repaired to the Engineer's acceptance level, if permitted, or removed and replaced, entirely at the Contractor's expense.
- B. All sections shall be inspected for general appearance, dimensions, soundness, etc. The surface shall be dense, close textured and free of blisters, cracks, roughness and exposure of reinforcement.
- C. Imperfections may be repaired, subject to the acceptance of the Engineer, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final acceptance.

1.04 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 23 SUBMITTALS, SUBMIT THE FOLLOWING:

- A. Shop Drawings

Structural design calculations and shop drawings, which shall be certified by a Professional Engineer retained by the system manufacturer or Contractor and licensed in the state where the system is to be installed.

B. Performance Documentation

The following documentation must be submitted by the Contractor and approved by the Engineer prior to the manufacture and delivery of any materials.

1. Manufacturing Experience

The stormwater chamber supplier shall provide evidence of at least 5 years of successful product design and use. The supplier shall provide an installation list of projects, model sizes installed and installation dates where the same type systems as specified herein have been designed and produced by the supplier.

C. Operation and Maintenance Manuals

Furnish the operation and maintenance manual for the stormwater treatment system. Operation and Maintenance procedures shall be as specified by the manufacturer.

PART 2 - PRODUCTS

2.01 MATERIALS AND DESIGN:

- A. Chamber, stone and fabric materials, and design shall conform to those indicated on the drawings, or, if applicable, in shop drawings and installation instructions provided by the system manufacturer.

2.02 MANUFACTURER:

- A. Each stormwater chamber system shall be of a type that has been installed and used successfully for a minimum of 5 years. The manufacturer of said system shall have been regularly engaged in the engineering design and production of systems for the physical collection of stormwater runoff during the aforementioned period.

2.03 STORMWATER PRETREATMENT COMPONENTS:

- A. The stormwater pretreatment component of the underground stormwater chamber system has been designed to meet the requirements of the Massachusetts Stormwater Handbook and has been approved by the local designated Stormwater Authority. Configuration of the stormwater pretreatment component of the system must be as indicated on the plans in order to comply with local approval. If the Contractor wishes to propose an alternative pretreatment approach, the Contractor must secure approval from the local Stormwater Authority for the alternative approach at no additional cost to the owner.

PART 3 - EXECUTION

3.01 INSTALLATION:

- A. Each stormwater chamber system shall be constructed according to the sizes shown on the Drawings and as specified herein. Install at elevations and locations shown on the Drawings or as otherwise required by the Engineer.

- B. Installation of Chambers, stone and fabric shall be completed as indicated in the manufacturer's installation instructions.

END OF SECTION