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 MECHANICAL**

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Notes to Specifier/Designer:

Note 1: Remove the section if not applicable to the specific project to create the project specific specification. The table of contents is to be edited to reflect the sections included under the revised specification. The sections not identified by a Note 1 shall not be removed from the project specific specification. All sections removed are to be reviewed and approved by VPTC Management Partners, LLC.

Note 2: Specific sections within this specification can be edited. Review the section and create the project specific specification where text is **[bracketed and bold type]**. All sections edited are to be reviewed and approved by VPTC Management Partners, LLC.
 Sections of the specification that are not identified as sections to be edited shall not be edited without the approval of the VPTC Management Partners, LLC.

Section 15010 – Basic Mechanical Requirements

Part 1 General

1.01 Related Documents:

- A. **General:** The requirements of the General and Special Conditions, Bidding and Contract Requirements - Division 0 and Division 1 apply to all Work under this Section.
- B. **Definition:** The term Contractor shall mean the Mechanical, Plumbing, and Fire Protection Contractor or subcontractor(s) responsible for work described under Mechanical, Plumbing, and Fire Protection sections.
- C. **R.F.P.:** If this Document is issued separately from the General Construction Documents, then all references throughout this Division to Division 0 and Division 1 shall mean VPTC Management Partners, LLC's Request for Proposal and its related instructions to the Contractors.

1.02 Description of Work:

- A. Drawings and Specifications:
 - 1. It is the intent of this Design Criteria, Plans, and Specifications to form a guide for the complete Mechanical, Plumbing, and Fire Protection installation, tested, commissioned, and ready for operation. The successful Contractor(s) shall be responsible for the final design (design build), sizing and installation of all Mechanical, Plumbing and Fire Protection work, to provide a complete workmanlike installation. Where capacities, sizes, styles, equipment, and similar items are indicated, this Specification shall be considered minimum requirements.
 - 2. The basis for design of the building is the VPTC Management Partners, LLC Master MEP Specification (latest edition prior to the issuance of these specifications). The job specific specifications have been selected to include only those sections applicable to this particular project. In the event that changes result in the addition of work not covered by these job specific sections, the additional work will be governed by the VPTC Management Partners, LLC Master MEP Specifications.
 - 3. The Architectural, Structural, Electrical, and Mechanical Drawings and Specifications discussed herein are hereby incorporated into and become a part of the Contract Document for Work under this Division. This Contractor shall examine all related Drawings and Specifications available for his review.
 - 4. This criteria establishes the minimum acceptable quality of equipment, material, and workmanship; the Drawings are shown for concept only and are not intended to dictate design, zoning, sizing, or distribution. This Contractor shall be responsible for the actual design to provide a complete, workmanlike system and installation.
 - 5. This criterion is intended to establish design guidelines and does not detail or dictate mechanical/electrical data needed for full coordination. Prior to submitting a proposal, this Contractor shall coordinate his design requirements with the listed electrical contractors so that loads and responsibilities are clearly understood. Lack of coordination will NOT be considered a basis or justification for adjustments in costs.

6. Innovations on the part of the Mechanical, Plumbing, and Fire Protection bidders are encouraged. The intent is to provide the Owner with a well-designed, state-of-the-art installation meeting, but not limited to, the requirements set forth in these Specifications.
 7. The Contract will not be awarded solely on the basis of price. Other important criteria, such as system zoning, economy of operation and maintenance, space requirements, flexibility, and comfort control will be evaluated.
- B. Work Included: This Work includes the furnishing of all design, coordination, labor, materials, equipment, fixtures, apparatus, and appurtenances required for complete installation of operating heating, ventilating, air conditioning, plumbing, and fire protection systems as indicated and specified, in place and ready for service.
- C. Work Described Under Other Sections: Requirements given within this Section apply to the Work of all Sections of this Division.
1. Finish painting is specified in other Divisions. Prime and protective painting of equipment is the responsibility of this Contractor, including touch-up of any paint damaged during construction.
 2. The Mechanical Contractor will be responsible for the installation of electrical or electronic temperature control and control interlock apparatus, other electrical apparatus, and wiring which is related solely to the HVAC temperature control system. Necessary conduit, wiring, boxes, and fittings, if required, shall be provided and installed as specified under Division 16. Line voltage power supply to temperature control equipment shall be the responsibility of the Electrical Contractor. Line voltage motor interlock wiring outside of the motor control center or motor starter shall be by the Electrical Contractor. The Mechanical Contractor shall coordinate all necessary power connections with the Electrical Contractor.
 3. Access doors in finished surfaces as specified under other Divisions shall be supplied and installed by this Contractor. Locations shall be as required for proper equipment access, including shutoff valves in all toilet chases. Locations shall be coordinated with the Architect prior to installation.
 4. Concrete housekeeping pads, materials, and supporting structures shall be located, dimensioned, and installed under this Division. This Contractor shall coordinate these requirements with the Structural Engineer. Provide pads under each piece of floor-mounted mechanical equipment and size so that pad extends 4" beyond each edge in Plan. Final dimensional requirements will be determined by the equipment furnished. Pads shall be a minimum of 3-1/2" high.
 5. Coordinate requirements for pits for sewage ejectors, storm water, and other pumps with the Structural Engineer. Dimensions and locations of pits shall be the responsibility of this Division.
 6. Owner-furnished equipment is furnished and installed under other Divisions. Proper HVAC and Plumbing provisions, including rough-in and final equipment connections, are included in the Work of this Division.
 7. Motors for all equipment shall be furnished and installed with the equipment furnished by this Contractor. Refer to Section 15030, "Electrical Provisions of Mechanical Work", for additional information.
 8. Motors and motor starters that are an integral part of the equipment are furnished under this Division with the driven equipment; all other motor starters, electrical power wiring

and connections are included in the Work of Division 16. Refer to Section 15030, "Electrical Provisions of Mechanical Work", for additional information.

1.03 1.03 Codes, Permits, and Standards:

A. General:

1. Install all work in accordance with all applicable codes, rules, laws, and regulations.
2. All work must meet requirements of the all applicable codes, rules, laws and regulations. This Contractor shall provide a code summary in the project specifications or drawings.
3. It is the Contractor's responsibility to obtain approvals necessary from VPTC Management Partners, LLC as well as to provide all fees necessary for permits, tests, and approval by the municipality, or any other agency, of this design and installation of the Mechanical, Plumbing, and Fire Protection systems. Any and all work necessary, whether or not shown or specified, but as required by the authorized building codes for general building, or any other code-required work not shown or specified, shall be included.
4. This Contractor shall prepare complete, professionally sealed, Plans and Specifications that shall be submitted to VPTC Management Partners, LLC for review.
5. This Contractor shall prepare complete, professionally sealed, Plans and Specifications that shall be submitted to the building officials along with the permit applications.
6. The Contractor, as a "designer/builder", shall submit proof of coverage of a professional liability insurance policy in accordance with their contract.

B. Precedence: Where Contract Document requirements are in excess of Code requirements and are permitted under the Code, the Contract Documents shall govern. None of the terms or provisions of the Drawings or specification shall be construed as waiving any of the rules, regulations or requirements of these authorities. In the event of conflict between the Contract Documents and the local enforcing authority, the latter shall rule. Any modifications resulting therefrom shall be made without additional cost to the Owner or VPTC Management Partners, LLC. This Contractor shall report any such modifications to VPTC Management Partners, LLC and secure their approval before proceeding.

1.04 Quality Assurance and Standards:

A. Materials/Methods: Manufacturers, materials, and methods described in the various sections of the Specifications, and indicated on the Drawings are intended to establish a standard of quality. It is not the intention of this Criteria Specification to discriminate against any product, material or method that is equal to the standards as indicated and/or specified, nor is it intended to preclude open, competitive bidding. Further, it should not be assumed that the listing of a specific manufacturer as an acceptable manufacturer means that the manufacturer's standard product will meet the requirements of the project design, Specifications and space constraints.

B. Alternative Products/Materials/Methods: Products by other reliable manufacturers, other materials, and other methods may be accepted provided they have equivalent capacity, construction, and performance. Under no circumstances shall any substitution be made without the prior written approval of VPTC Management Partners, LLC. Wherever a definite product, material or method is specified and there is not a statement that another product, material or method will be acceptable, it is the intention of VPTC Management Partners, LLC that the specified product, material or method is the only one that shall be used without prior

approval. Wherever a definite material or manufacturer's product is specified and the Specification states that products of similar design and equal construction from the specified list of manufacturers may be provided, it is the intention of VPTC Management Partners, LLC that products of manufacturers that are specified are the only products that will be acceptable and that products of other manufacturers will not be considered for substitution without prior written approval.

1. For an alternative product/material/method to be considered, the Contractor must provide VPTC Management Partners, LLC with sufficient information to make a determination. The information should include a description of the product/material/method, drawings or sketches showing the impact on the physical constraints of the project, indications of the affect on the construction schedule and any cost implications. VPTC Management Partners, LLC will review the information with the Owner or Owner's representative and VPTC Management Partners, LLC's engineering consultant. The Contractor shall provide at least four copies of the information he wants to be considered.

- C. Alternative Equipment: Where substituted or alternative equipment is used on the project, it shall be the responsibility of the Contractor or Subcontractor involved to verify that the equipment will fit in the space available, including all required Code and maintenance clearances, and to coordinate all equipment requirements and provisions with the Mechanical (HVAC) and Plumbing Design and all other Contractors.

- D. Standards: Refer to Division 1 for general administrative/procedural requirements related to compliance with applicable standards. This Work shall meet the standards set forth in the applicable portions of the following recognized standards:
 1. ADC Air Diffusion Council
 2. AGA American Gas Association
 3. AMCA American Movement and Control Association
 4. ANSI American National Standards Institute
 5. ARI American Conditioning and Refrigeration Institute
 6. ASHRAE American Society of Heating, Refrigerating & Air-Conditioning Engineers
 7. ASME American Society of Mechanical Engineers
 8. ASPE American Society of Plumbing Engineers
 9. ASSE American Society of Sanitary Engineering
 10. ASTM American Society for Testing and Materials
 11. AWS American Welding Society
 12. AWWA American Water Works Association
 13. CDA Copper Development Association
 14. CE Corps of Engineers (U. S. Department of the Army)
 15. CISPI Cast Iron Soil Pipe Institute
 16. ETL Electric Testing Laboratory

17. FM	Factory Mutual Engineering Corp.
18. FS	Federal Specification (General Services Admin.)
19. IRI	Industrial Risk Insurers
20. MCAA	Mechanical Contractors Association of America
21. MIL	Military Standardization Documents (U. S. Dept. of Defense)
22. MSS	Manufacturers Standardization Society of the Valve and Fittings Industry
23. NEC	National Electrical Code (by NFPA)
24. NEMA	National Electrical Manufacturers Association
25. NFPA	National Fire Protection Association
26. OSHA	Occupational Safety Health Administration (U. S. Department of Labor)
27. PDI	Plumbing and Drainage Institute
28. SMACNA	Sheet Metal & Air Conditioning Contractors' National Association
29. UL	Underwriters' Laboratories, Inc.

1.05 Site Visit and Familiarization:

- A. General: Become familiar with the Criteria Drawings and Specifications, examine the premises, and understand the conditions under which the Contract shall be performed, prior to submitting a bid.
- B. Site: Be informed of the site conditions, verify locations of new and existing equipment, and determine exact requirements for connections.
- C. Coordination: Tender of a proposal for this project infers that the Contractor has visited the site and has become familiar with the Drawings and site conditions and has included in his proposal, all work necessary to properly install the systems on the project.

1.06 Design Drawings, Equipment Data, and Calculations:

- A. General: Locate all items during design coordination and on-the-job measurements and in accordance with the Contract Documents. Cooperate with other trades to ensure project completion as indicated.
- B. Location: Where locations of diffusers, grilles, and other exposed air devices, fire hose cabinets, and plumbing items are not described in the construction documents, review locations of items with the Architect and/or VPTC Management Partners, LLC prior installation. Locations shall not be determined by scaling drawings and shall not be installed unless coordinated with the trades affected. Plumbing fixtures, fire hose racks, and cabinets shall be mounted at the heights directed by VPTC Management Partners, LLC, and as required by code. Contractor shall be responsible for costs of redoing work of trades necessitated by failure to comply with this requirement.
- C. Equipment Drawings: This Contractor shall furnish complete, easily readable material and equipment layouts and brochures, control, interlock, and riser diagrams, Shop Drawings,

manufacturers' guarantees and information or samples as necessary for all equipment and material he proposes to furnish and install to VPTC Management Partners, LLC, and obtain approval prior to beginning of Work. Shop Drawings shall indicate equipment provided including indications of options. Any work started before receiving approval on any of this data will be at the Contractor's risk.

- D. Design Drawings: Provide complete drawings with all sizes, models, and equipment identification, input capacities, riser diagrams, and similar items sealed by a registered professional engineer. Equipment shall be drawn to scale and all major pieces of equipment such as heat pumps, air handling units, boilers, heat exchangers, control panels, and similar items, shall be clearly dimensioned from the nearest grid line or other clearly defined building elements. Load calculations and design data shall be furnished to VPTC Management Partners, LLC. Design drawings are to be complete prior to the start of construction of the project. Drawing content shall be such that the design is ready for construction.
- E. Drawing Submissions: All drawings and data shall be submitted in sufficient quantity so that VPTC Management Partners, LLC can keep four copies.
- F. Revisions: Any layout changes during the progress of the job shall be submitted to VPTC Management Partners, LLC for approval.

1.07 Discrepancies:

- A. Clarification: Clarification shall be obtained before submitting a proposal for the Work under this Division as to discrepancies or omissions from the Contract Documents or questions as to the intent thereof.
- B. Detailed Instructions: Should it appear that the work hereby intended to be done or any of the materials relative thereto, is not sufficiently detailed or explained in the Drawings or Specifications, then the Contractor shall apply to VPTC Management Partners, LLC for such further Drawings or explanations as may be necessary, allowing a reasonable time for VPTC Management Partners, LLC to supply them. The Contractor shall conform to them as a part of the Contract without additional cost to the Owner or VPTC Management Partners, LLC.
- C. Interpretations: Should any doubt or question arise respecting the true meaning of Drawings or Specifications, reference shall be made to VPTC Management Partners, LLC, whose decision shall be final and conclusive. No alleged statement by the Construction Manager will be accepted as an excuse for inferior work.
- D. Contractor Agreement: Consideration will not be granted for misunderstanding of the amount of work to be performed. Tender of a proposal conveys full Contractor agreement of the items and conditions specified, shown, scheduled, or required by the nature of the project.

1.08 Utilities:

- A. General: Utility information where shown on the Criteria Drawings has been shown based upon data obtained from the site survey and the agencies having jurisdiction and are accurate to the best of the knowledge of VPTC Management Partners, LLC.
- B. Coordination: The Contractor shall be responsible for field verification of the actual location of site utilities and shall make modifications necessary for connection to or construction around those utilities at no additional cost.

1.09 Pre-Design Conference:

- A. Conference(s): Upon the award of this Contract, and prior to commencing any work, the Contractor, his Engineer, and his designated major subcontractors, shall confer with the Architect and VPTC Management Partners, LLC concerning the Work under this Contract. The conference(s) shall be at a mutually agreeable place and time.

1.10 Submittals:

- A. General: Submittals required for this project shall include, but not be limited to:
1. Shop Drawings and Product Procedure Submittals,
 2. Certifications and Test Reports,
 3. Operating and Maintenance Manuals, and
 4. Warranties (Guarantees)
 5. Refer to Division 1 for additional submittal requirements.
- B. Shop Drawings and Product Brochure Submittals: The Contractor shall submit a minimum of eight complete bound sets of Shop Drawings and complete data covering each item of equipment or material. The terms "Submittal" and "Shop Drawing" in this Specification are defined as either product literature, samples of equipment, or actual Shop Drawings. The first submittal of each item requiring a submittal must be received by VPTC Management Partners, LLC in accordance with the project schedule. VPTC Management Partners, LLC shall not be responsible for any delays or costs incurred due to excessive Shop Drawing review time where the first submittal is received more than 60 days after contract award. The Architect and VPTC Management Partners, LLC will retain four (4) copies of all Shop Drawing submittals for their files. Where full size Drawings are involved, submit two prints and one reproducible in lieu of eight sets.
1. Contractor shall prepare complete submittals that include all pertinent information about the product. A single Shop Drawing shall not contain information from more than one Specification section, but a single Specification section may be subdivided into separate submittals for items or equipment that are specified in that section. Shop Drawings shall be separately bound by complete or partial Specification section. Where a single Shop Drawing contains information from more than one Specification section, it will be marked "NOT ACCEPTED" and returned. Each Shop Drawing shall include the following items enclosed in a suitable binder, Shop Drawings that do not comply with the above requirements will be marked "NOT ACCEPTED" and returned to the Contractor:
 - a. A cover sheet with the name of the Project, and the Subcontractor making the submittal. The cover sheet shall also contain the Specification section number applicable to the item or items submitted, the item nomenclature and description and a submittal number. HVAC, plumbing and fire protection submittals shall be numbered sequentially by Specification section with a sequence suffix (e.g. 15640-1, 15640-2, 15700-1, etc.). Resubmittals shall be numbered with the original submittal number plus an R in the sequence suffix (e.g. the resubmittals of submittal 15640-1 would be 15640-1R1, 15640-1R2).
 - b. A list of variations. This page shall list all variations, including unfurnished or additional items or features between the submitted equipment and the specified equipment. If there are no variations, then this page shall state "No Variations".

Where variations affect the work of other contractors, then the contractor shall certify on this page that these variations have been fully coordinated with the affected contractors and that all expenses associated with the variations will be paid by the submitting contractor.

- c. Equipment information including manufacturer's name and designation, size, performance, and capacity data. All applicable Listings, Labels, Approvals and Standards shall be clearly indicated.
 - d. Dimensional data and actual sketches as applicable to show that the submitted equipment will fit the space available with all required Code and maintenance clearances.
 - e. Identification of each item of material or equipment matching that indicated on the Drawings.
 - f. Sufficient pictorial, descriptive and diagrammatic data on each item to show its conformance with the Criteria Drawings and Specifications. Any options or special requirements shall be so indicated. All applicable information shall be clearly indicated with arrows or another approved method. Any non-applicable information shall be crossed out.
 - g. Additional information as required in other sections of this Division.
 - h. Certification by the Contractor that the material submitted is in accordance with the Contract Documents, signed and dated.
 - i. An authorized officer of the manufacturer or testing agency shall certify reports or information requiring certification.
 - j. Certified Shop Drawings showing dimensions, loading details, anchor bolt locations, and inserts required for each piece of equipment set on concrete in sufficient time to cause no delay in the Work.
 - k. Equipment and material submittals shall show sufficient data including all performance curves, sound data, recommended installation details, and sufficient data to indicate complete compliance with the Contract Documents, including proper sizes, clearances, capacities, materials, and finishes. All equipment capacity data shall be made with ARI certified selections.
- C. Required Shop Drawing Submittals: Submit Shop Drawings including but not limited to the following items:
- 1. Electric Heating Cable - Refer to Section 15070
 - 2. Seismic Controls for Mechanical – Refer to Section 15075
 - 3. Electronic Variable Speed Drives - Refer to Section 15080
 - 4. Valves Refer to Section - 15100
 - 5. Mechanical Pumps - Refer to Section 15170
 - 6. System Insulation - Refer to Section 15250
 - 7. Office Building Fire Protection Systems - Refer to Section 15300

8. Plumbing Piping Systems - Refer to Section 15400
 9. Plumbing Pumps - Refer to Section 15410
 10. Floor and Roof Drains - Refer to Section 15420
 11. Plumbing Fixtures and Trim - Refer to Section 15440
 12. Electric Water heaters - Refer to Section 15458
 13. Mechanical Piping Systems - Refer to Section 15510
 14. Air Removal and Water Expansion System - Refer to Section 15514
 15. Water Treatment System - Refer to Section 15545
 16. Hot Water Boilers - Refer to Section 15550
 17. Air Cooled Condensing Units - Refer to Section 15675
 18. Split System Fan Coil Units - Refer to Section 15680
 19. Fluid Coolers - Refer to Section 15730
 20. Electric Heating and Cooling - Refer to Section 15833
 21. Unit Heaters - Refer to Section 15834
 22. Air Turnover Units - Refer to Section 15836
 23. Fan and Ventilators - Refer to Section 15860
 24. Ductwork - Refer to Section 15891
 25. VAV and Fan-Powered Air Terminal Units - Refer to Section 15931
 26. Air Outlets and Inlets - Refer to Section 15940
 27. Building Automation System - Refer to Section 15950
- D. Shop Drawing Submittal Review: Shop Drawings will be reviewed for general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. Any action shown in review comments is subject to the requirements of the Contract Documents. The submitting Contractor is responsible for: dimensions that shall be confirmed at the job site; fabrication processes and techniques of construction; coordination of his work with that of all other trades; and the satisfactory performance of his work.
1. The Shop Drawing review time in VPTC Management Partners, LLC's office will be minimum of two weeks per review, exclusive of transmittal time, and this review time shall be considered by the Contractor when scheduling his work on the project.
 2. The Architect's review or approval and VPTC Management Partners, LLC's review of Shop Drawing shall not relieve the Contractor of the responsibility for errors, omissions or deviations that may be contained in the submittals. If the Contractor proceeds on the basis of undetected errors, omissions or deviations in reviewed Shop Drawings, it shall be at his sole responsibility and the review does not allow deviations from the requirements of the Contract Documents. Noting some errors, omissions, and deviations but

overlooking other errors, omissions, and deviations does not grant the Contractor permission to proceed in error. Regardless of any information contained in the Shop Drawing or VPTC Management Partners, LLC's review thereof, the Contract Documents shall govern the Work and are neither waived nor superseded by the Shop Drawing review.

3. At the time equipment and materials are delivered to the job site, it shall be the responsibility of the submitting Contractor to check all equipment and materials for conformance with the Contract Documents and submittals including comments and revisions made to the submittal during the submittal process. If equipment or materials are determined by the contractor to be in non-conformance, it shall be the responsibility of the contractor to bring equipment and materials into conformance with the Contract Documents. The contractor shall also notify VPTC Management Partners, LLC of any corrections that need to be made.
4. Inadequate or incomplete Shop Drawings will not be reviewed by VPTC Management Partners, LLC and will be returned to the Contractor marked "NOT ACCEPTED" for completion and resubmittal.
5. Shop Drawings will be marked "REVIEWED", "REVIEWED WITH COMMENT", "REVISE AND RESUBMIT", or "NOT ACCEPTED" when reviewed by VPTC Management Partners, LLC. The definitions of these terms for review purposes is as follows:
 - a. **REVIEWED** - The Shop Drawing was reviewed and no deviations from the general conformance with the design concept and general compliance with the information given in the Contract Documents were noted.
 - b. **REVIEWED WITH COMMENTS** - The Shop Drawing was reviewed and found to have either minor deviations from the requirements of the Contract Documents or information missing from the submittals. A complete Shop Drawing resubmittal is not required, however, a written response to all review comments shall be submitted in the format used for a resubmittal.
 - c. **REVISE AND RESUBMIT** - The Shop Drawing was reviewed and major deviations from general conformance with the design concept and general compliance with the information given in the Contract Documents were observed as noted. The Shop Drawing shall be revised to eliminate the deviations noted and resubmitted.
 - d. **NOT ACCEPTED** - The Shop Drawing was reviewed and is not in general conformance with the design concept or in compliance with the information given in the Contract Documents, as noted. A revised Shop Drawing submittal for the specified equipment or materials shall be resubmitted.
6. Division 1 and General Conditions requirements concerning Shop Drawing submittal review are not applicable to this Division.
7. Materials and equipment which are purchased or installed prior to Shop Drawing review shall be at the risk of the Contractor and the cost for removal and replacement of such materials and equipment and related work which is judged unsatisfactory by VPTC Management Partners, LLC for any reason, shall be at the expense of the Contractor.
8. Shop Drawings shall be complete and checked prior to submission to VPTC Management Partners, LLC for review. The contractor shall stamp and date each section indicating review and acceptance of that shop drawing.

- E. Certifications and Test Reports: Test reports and certifications shall be provided as specified in sections 15995 Mechanical Commissioning and 15990 HVAC Operational Testing. Additional testing described elsewhere in the specifications is also required as specified.
- F. Operating and Maintenance Manuals: Submit three (3) copies of Operating and Maintenance Manuals to VPTC Management Partners, LLC. Manuals shall be bound in rigid cover, 3-ring binders with spine and cover labels and shall provide operating and maintenance information for every piece of equipment furnished under this Specification. All sections shall be typed and indexed into sections and labeled for easy reference. Bulletins containing information about equipment that is not installed on the project shall be properly marked up or stripped and reassembled. All pertinent information required by the Owner for proper operation and maintenance of equipment supplied by Division 15 shall be clearly and legibly set forth in memoranda that shall, likewise, be bound with bulletins. As a minimum, the following information shall be provided as applicable:
1. Complete description of each system, item of equipment, and apparatus provided under this Division, including ratings, capacities, performances, data and curves, characteristics identifying name and number, locations, and wiring diagrams.
 2. Fully detailed parts lists, including all numbered parts and recommended spare parts, of each item of equipment and apparatus provided under this Division.
 3. Manufacturer's printed instructions describing operation, service, maintenance, troubleshooting, and repair of each item of equipment and apparatus.
 4. Typewritten record of tests made of materials, equipment, and systems included under this Division. Such records shall state the dates the tests were conducted, name(s) of person(s) making and witnessing the tests, and citing any unusual conditions relevant to the tests.
 5. Temperature control wiring diagrams complete with instructions outlining each sequential step in the start up and shutdown of the heating/cooling system. Include precautions and instructions for servicing each item of the system.
 6. Identifying names, name tags designations and locations for all equipment.
 7. Valve tag lists with valve number, type, color coding, location and function.
 8. Equipment and motor name plate data.
 9. Approved Shop Drawing submittals.
 10. Fabrication drawings.
 11. Equipment and device bulletins and cut sheets clearly highlighted to show equipment installed on the project and including performance curves and data as applicable.
 12. Maintenance instructions clearly highlighted to show all required periodic maintenance and lubrication.
 13. Wiring diagrams.
 14. Operating instructions clearly highlighted to show proper operating procedures for all equipment.
 15. Exploded parts views and parts lists for all equipment and devices.

16. Color-coding charts for all painted equipment and conduit.
 17. Location and listing of all spare parts and special keys and tools furnished to the Owner.
- G. Tools: Provide and deliver to VPTC Management Partners, LLC any special tools required for maintenance of systems, equipment, and apparatus installed under this Division prior to requesting final acceptance of the installation.

1.11 Project Record Documents:

- A. Site Prints: Maintain a set of clearly marked black line prints of the Contract Drawings at the job site which shall be used for recording the work details, final size, location, interrelation, and similar items of all work under this Division. This set of Drawings shall be corrected daily as the Work progresses and shall clearly indicate all changes to suit field conditions, changes made by "Field Order" or "Change Order", accurate dimensions of all buried or concealed work, precise locations of all concealed work, locations of all concealed valves, controls and devices and any deviations from the work shown on the Construction Documents which are required for coordination. All dimensions shall be to at least two permanent structure points.
- B. Upon completion of the work, the Contractor shall transfer all marks from the site prints to a set of reproducible record "as-built" Drawings using red pencil. The reproducible record "as-built" Drawings shall have the Design Engineer's name and seal removed or blacked out and shall be clearly marked and signed on each sheet.
- C. Review: Prior to final acceptance of the Work of this Division, the Contractor shall submit one reproducible and two black line prints of properly certified Record Drawings to the Design Engineer and VPTC Management Partners, LLC for review and shall make changes, corrections, or additions as the Design Engineer and VPTC Management Partners, LLC may require to the Record Drawings. Upon completion of review and acceptance by the VPTC Management Partners, LLC, the Contractor shall have all data transferred to the original CAD files. “. .

1.12 Coordination of Mechanical Work:

- A. General: Refer to Division 1 for general coordination requirements applicable to the entire work. It is recognized that the Contract Documents are diagrammatic in showing certain physical relationships that must be established within the mechanical work, and in its interface with other work including structural impact, utilities and electrical work and that such establishment is the exclusive responsibility of the Contractor. The Drawings show diagrammatically the sizes and locations of the various ductwork and piping systems and equipment items and the sizes of the major interconnecting ducts and pipes, without showing exact details as to elevations, offsets, control lines, and installation details.
1. Arrange mechanical work in a neat, well organized manner with services running parallel with primary lines of the building construction. A minimum of 7-1/2" inch clear space above future or existing ceilings is to be maintained for future tenant finish work.
 2. The Contractor shall carefully lay out his work at the site to conform to the architectural and structural conditions, to avoid obstructions and to provide proper grading of lines. Exact locations of outlets, apparatus and connections thereto shall be determined by reference to detail Drawings, equipment Drawings, roughing-in Drawings, etc., by measurements at the building and in cooperation with other Contractors and in all cases shall be subject to the approval of VPTC Management Partners, LLC. Relocations

necessitated by the conditions at the site or directed by VPTC Management Partners, LLC shall be made without any additional cost to the Owner.

3. All ducts and pipes except those in the various equipment rooms, in unfinished spaces or where specifically designated herein or on the Drawings shall be run concealed in furring, plenums and chases. Wherever conditions exist which would cause any of these items to be exposed in finished spaces, the Contractor whose work is involved shall immediately call the situation to the attention of VPTC Management Partners, LLC and shall stop work in those areas until VPTC Management Partners, LLC directs the resumption of the work. Submit for approval a Shop Drawing for any change in piping, equipment placement, ductwork, etc.
4. Equipment chosen to fit within the available space with all required Code and maintenance clearances and shall be installed as shown. Every effort has been made to also accommodate equipment of other approved manufacturers, however since equipment and access space requirements vary, the final responsibility for installation access and proper fit of substituted equipment rests with the Contractor.
5. Piping interference shall be handled by giving precedence to pipe lines that require a stated grade for proper operation. Where space requirements conflict, the following order of precedence shall, in general, be observed:
 - a. Building Lines,
 - b. Structural Members,
 - c. Soil and Drain Piping,
 - d. Condensate Piping,
 - e. Sprinkler Piping,
 - f. Vent Piping,
 - g. Supply Ductwork,
 - h. Exhaust Ductwork,
 - i. Chilled Water and Heating Hot Water Piping,
 - j. Domestic Water Piping, and
 - k. Electrical Conduit.
6. Locate operating and control equipment properly to provide easy access. Arrange entire mechanical work with adequate access for operation and maintenance.
7. Advise other trades of openings required in their work for the subsequent move in of large units of mechanical work (equipment).
8. Coordinate all items that will affect the installation of the work of this Division. This coordination shall include, but not be limited to: structural weight, voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.
9. When submitting Shop Drawings on the project, this Contractor is indicating that all necessary coordination has been completed and that the systems, products and

equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all other Contractors and Subcontractors.

B. Coordination:

1. This Contractor shall coordinate his work with other trades as required to provide the best overall systems installation. Due to the inherent interrelationship between the Mechanical and Electrical Contractor, it is imperative that all aspects of the mechanical work be coordinated with the Electrical Contractor prior to bid.
2. This contractor shall coordinate his work with the sub-contractors performing his scope of work. This includes coordinating the equipment suppliers and the sub-contractors to ensure technical support and information is available as needed to complete his scope of work.
3. In case of conflict, VPTC Management Partners, LLC shall decide the proper location or arrangement, and any costs in revision or relocating equipment or material shall be at the expense of the Contractor responsible for the work.
4. Prepare complete design documents and coordination drawings (Shop Drawings) showing the actual physical dimensions (at accurate scale) required for the installation of mechanical and electrical equipment fitted within the allotted spaces. Prepare and submit coordination drawings prior to purchase-fabrication-installation of any of the elements involved in the coordination.

1.13 Materials and Workmanship:

- A. General: Materials and equipment shall be new, of best grade and quality, and standard products of reputable manufacturer's regularly engaged in the production of such materials and equipment.
- B. Workmanship: Work shall be executed and materials installed in accordance with the best practice of the trades in a thorough, substantial, workmanlike manner by competent workmen, presenting a neat appearance when completed.
- C. Manufacturer's Recommendations: With exceptions as specified or indicated on the Drawings or in the Specifications, apply, install, connect, erect, use, clean, and condition manufactured articles, materials, and equipment per manufacturer's current printed recommendations. Copies of such printed recommendations shall be kept at the job site and made available as required.

1.14 Space Requirements:

- A. General: Determine in advance of purchase that the equipment and materials proposed for installation will fit into the confines indicated, leaving adequate clearances for adjustments, repair, or replacement.
- B. Clearance: Allow adequate space for clearance in accordance with requirements of the code and local inspection department. In addition, all equipment shall be installed where the equipment can be maintained per the manufacturer's recommendations.
- C. Scheduled Equipment: The design shown on the Drawings is based on the equipment scheduled.

- D. Responsibility: Since space requirements and equipment arrangement vary for each manufacturer, the responsibility for access and proper fit rests with the Contractor.
- E. Review: Final arrangements of equipment to be installed shall be subject to the review of VPTC Management Partners, LLC.

1.15 Safety Regulations:

- A. All mechanical work shall be performed in compliance with all applicable and governing safety regulations. All safety lights, guards, signs, and other safety materials and provisions required for the performance of the mechanical work shall be provided by and operated by the Mechanical contractor.

1.16 Delivery, Storage, and Handling of Materials:

- A. General: Protect all materials and equipment to be installed under this Division from physical and weather damage.
- B. Scope: Work under this Division shall include, but not limited to:
 - 1. Shipping from point of manufacture to job site,
 - 2. Storage on site with proper protection as required,
 - 3. Hoisting and scaffolding of materials and equipment included in this Division, and
 - 4. Ensuring safety of employees, materials, and equipment using such hoisting equipment and scaffolding.
- C. Coordination: All large pieces of apparatus which are to be installed in the building and which are too large to permit access through doorways, stairways or shafts shall be brought to the job by the Contractor and shall be placed in the spaces before enclosing structure is completed. All apparatus shall be cribbed up from the floor by Contractor and shall be covered with tarpaulins or other protective covering where required for protection.

1.17 Cutting and Patching:

- A. General: Coordinate penetrations and place equipment in time to avoid cutting new construction.
- B. Approval: If holes or sleeves are not properly installed and cutting and patching becomes necessary, it shall be done at no change in Contract amount. Undertake no cutting or patching without first securing written approval from VPTC Management Partners, LLC. Patching shall create a surface that is structurally and aesthetically equal to the surface surrounding the area patched and shall be performed by the trade whose work is involved, at no change in the Contract amount.
- C. Protection: Openings through exterior walls or roofs shall be provided with suitable covers while they are left open to protect the property or materials involved. Any openings through walls below grade shall be properly protected to prevent entrance of water or other damaging elements.

1.18 Noise and Vibration:

- A. General: Warrant the heating, ventilating, air conditioning systems, and their component parts to operate without objectionable noise or vibration. Noise from systems or equipment which results in noise within occupied spaces above the recommended levels shall be considered objectionable. Vibration shall not be apparent to the senses in occupied areas of the building. Objectionable noise, vibration, or transmission thereof to the building shall be corrected at no cost to VPTC Management Partners, LLC.
- B. Noise level criteria shall comply with the levels outlined in the ASHRAE Fundamentals Handbook, Chapter 7.
- C. Special attention should be paid to the areas directly adjacent to mechanical rooms and directly below rooftop mechanical equipment. Necessary vibration isolators, duct silencers, and other design provisions shall be included as required to meet the criteria outlined above. Coordinate with architect and other trades if special architectural construction or structural isolation is required. Ductwork shall be sized and designed to avoid objectionable noise, especially in medium pressure duct systems.
- D. Verification: Should a question arise of whether noise and vibration in a particular space or piece of equipment meet the above criteria, the Contractor shall be responsible for providing the services of an approved vibration or acoustic consultant to verify criteria compliance.

1.19 Cleaning, Adjusting, and Start-up:

- A. Start-up Services: Where required to validate manufacturers warranty or otherwise specified in these specifications or construction documents, provide a factory-authorized representative for testing and start-up of equipment and systems for any individual item of heating, ventilating, air conditioning and plumbing equipment and instruction of Owner's operating personnel. Provide to VPTC Management Partners, LLC a copy of the start-up report generated by the factory-authorized representative and/or provide the manufacturer's start-up checklist completed by the installing contractor. In the event that the checklist is not available then in order to certify that these services have been performed include a properly executed invoice for these services or a letter from the manufacturer stating that the equipment and or system has been started per their recommendations.
- B. Lubrication: Provide means for lubricating all bearings and other machine parts. Where applicable, extend a lubrication tube with suitable fitting to an accessible location and suitably identify it where lubrication fittings are concealed or inaccessible. Lubricate all parts requiring lubrication and keep them adequately lubricated until final acceptance by the Owner.
- C. Air Filters:
 - 1. Air filters shall be installed on all equipment so equipped prior to initial start-up.
 - 2. New air filters shall be installed on all equipment so equipped prior to final turnover.
 - 3. Where equipment is used for temporary heating or cooling, temporary filter media shall be provided and installed and removed by the mechanical contractor.
 - 4. Upon project completion provide one spare set of all filter sizes for Owner stock.
- D. Testing, Adjusting, and Balance: Refer to Section 15990, "HVAC Operational Testing, Adjusting, and Balancing", for requirements.
- E. Clean-up: Each Contractor shall clean away from the job site all debris, surplus material, and similar items, resulting from his work or operations, leaving the job and equipment in a clean

condition. Each Contractor shall thoroughly clean all pieces of equipment, ductwork, fixtures, and similar items, leaving the installation in a first class condition.

1.20 Final Review:

- A. General: Upon completion of the Work, perform a final test of the entire system.
1. The system shall be operating properly with all water and air volumes balanced and all temperature controls adjusted.
 2. After the final test, any changes or corrections noted as necessary for the Work to comply with these Specifications or the Drawings shall be accomplished without delay in order to secure final acceptance of the Work.
 3. The date for the final test shall be sufficiently in advance of the Contract completion date to permit execution, before expiration of the Contract, of any adjustments or alterations which the final acceptance tests indicate as necessary for the proper functioning of all equipment. Any such modifications shall be completed within the time allotted for completion of the Contract. Retests shall be conducted as directed and shall be of such time duration as necessary to ensure proper functioning of adjusted and altered items. Retests shall not relieve the Contractor of completion date responsibility.
 4. Certificates, including certificates of occupancy from local authorities and documents required herein, shall be completely in order and presented to VPTC Management Partners, LLC at least one week prior to the review.
- B. System Performance Demonstration: All installing contractors are required to demonstrate to the owner, the operation of all systems installed. Refer to specification section 15995 Mechanical Commissioning for additional information and the Commissioning requirements for each system.
1. Qualified Person: Individuals knowledgeable of the systems and persons approved by VPTC Management Partners, LLC, shall be present at this final inspection to demonstrate the system and prove the performance of the equipment.

1.21 Owner Instruction:

- A. General: This Contractor and appropriate factory-trained representatives shall instruct the Owner's representative in the proper operation and maintenance of all systems and equipment and shall explain all warranties.
- B. Outline: Prior to instruction of Owner Personnel, prepare a typed outline, listing the subjects that will be included in this instruction, and submit the outline for review by VPTC Management Partners, LLC.
- C. Certification: At the conclusion of the instruction period obtain the signature of each person being instructed on each copy of the approved outline to signify that he has a proper understanding of the operation and maintenance of the systems and resubmit the signed outlines.
- D. Other Requirements: Refer to other Division 15 Sections for additional Operator Training requirements.

1.22 Contractor Warranties and Guarantees:

- A. General: Contractor shall guarantee and provide warrantee for all material and equipment installed by him against defects in workmanship and material for a period of 12 months after the date of substantial completion. The contractor shall repair or replace any materials or equipment developing such defects within that time, promptly on due notice given him by the Owner and at Contractor's sole cost and expense.
- B. Equipment: All equipment bearing a manufacturer's guarantee and warrantee, such as motors, compressors, condensers, heat exchangers, water heaters, blowers, controls, and similar items, shall be construed to have an extended guarantee and warrantee to the Owner by the manufacturer. Any such equipment that proves defective in materials or workmanship within the guarantee period is to be replaced by the Contractor in accordance with the manufacturer's guarantee.
- C. Start-up: The Mechanical Contractor shall provide instructions and equipment starting service on new equipment for one complete year after date of final acceptance of the work by the Owner, at Contractor's sole cost and expense.

END OF 15010 – BASIC MECHANICAL REQUIREMENTS

Section 15030 – Electrical Provisions of Mechanical Work

Part 1 - General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Furnish and install all motors required for equipment furnished under this Division. All motors shall be factory installed on equipment whenever possible. Motor controllers will, in general, be furnished and installed under Division 16 except for motor controllers which are integrally mounted on equipment or which are specifically specified under this Division.
1. In general, all motorized or electrically operated equipment will be set in place by the furnishing Contractor with all integrally mounted starters, controls and disconnect switches installed.
 2. Where integral starters and motor controls are not provided with equipment and are not furnished by another contractor, Division 16 shall furnish, install and connect all starters and disconnect switches required per code and proper operation of that equipment. This contractor shall coordinate these requirements with Division 16.
 3. All interconnecting wiring, conduit and connections between motors and starters and related control devices shall be the responsibility of the Division furnishing the control device.
 4. Division 16 shall furnish miscellaneous 120 volt control power as required for systems and equipment furnished by other Divisions. This control power shall be furnished by Division 16 for all systems and equipment and where shown on the Drawings or approved shop drawings by the Division furnishing the system or equipment.
 5. All starters and controllers for non-120 volt equipment and motors shall be furnished with control power transformers and control power circuits will not be required.
 6. Equipment and devices shall comply with applicable standards of NEMA and must be UL listed or approved by a code accepted agency. Assemblies, not just components, must be UL listed, where required by code. All work shall comply with the National Electrical Code.

1.03 Quality Assurance:

- A. Manufacturers: Provide products produced by one of the following:
1. Baldor

2. Century/Gould
3. General Electric
4. Louis Allis
5. Reliance
6. Siemens-Allis
7. US Motors
8. Westinghouse
9. Lincoln

1.04 Submittals:

- A. Shop drawing submittals shall include, but not be limited to, the following information:
1. Manufacturer's name and cut sheets
 2. Motor type
 3. Horsepower
 4. Voltage/Phase/Hertz
 5. RPM
 6. Service factor
 7. Insulation class
 8. NEC code number
 9. Motor efficiency and testing method

Part 2 - Products

2.01 Electric Motors:

- A. General: Motor voltages shall be as follows, unless noted or specified otherwise:
1. 1 hp and larger - 460 volts, 3-phase, 60 Hz,
 2. Smaller than 1 hp - 120 volts, 1-phase, 60 Hz, and
- B. Motors: All motors shall be started across-the-line, unless 30 hp or greater. Motors of 30 hp or greater shall be started via a Wye-Delta, closed transition configuration. All motors shall have copper windings. Motors shall be selected with low starting current and shall be designed for continuous duty to attain the running torque and pull-in torque required to suit the load. Motors for indoor-protected use shall be open drip-proof (ODP) construction, unless noted or specified otherwise. All motors exposed to the weather or contaminated environments shall be of the totally-enclosed fan-cooled (TEFC) or totally-enclosed air over (TEAO) type. All motors shall be single speed (1750 rpm), unless otherwise noted or specified. Two-speed motors shall be two-speed, one-winding (2S-1W) or two-speed (1750/1200 rpm), two-winding (2S-2W), unless otherwise noted or specified. All motors used with wye-delta reduced voltage starting shall be wound with taps for wye-delta reduced voltage starting. Refer to other Sections herein and the Electrical Drawings for two-speed motors and motors with reduced voltage starting.
- C. Frequency Inverter Motors: All motors which will be controlled by a frequency inverter for variable speed operation shall be selected in coordination with the frequency inverter requirements and shall be certified for this duty.

- C. Service Factor: All open motors shall be 1.15 service factor and all enclosed motors shall be 1.0 service factor, unless specified otherwise. All motors shall be rated for continuous duty. All motors shall be selected at design conditions without exceeding nameplate data assuming a 1.0 service factor.
- D. Bearings: Motors shall have either sealed ball bearings or field lubricated type ball bearings. Field lubricated ball bearings shall be drilled for grease fittings and have fittings installed. Where motors are installed inside equipment, extended grease fittings shall be provided.
- E. Balancing: Motors shall be statically and dynamically balanced and tested at the factory prior to shipment and shall be selected for quiet operation.
- F. Insulation: Open single phase motors shall have Class A or Class B insulation, open 3 phase motors shall have Class B insulation and all enclosed motors shall have Class F insulation.
- G. Single Phase Motors: All single phase motors shall be capacitor start or permanent split capacitor type selected to suit the load served. Single phase motors 1/4 hp and smaller shall have internal thermal protection.
- H. End Bells: All open motors 10 hp and smaller shall have cast aluminum end bells with steel frames. All open motors 15 hp and larger and all enclosed motors shall have cast iron housings.
- I. Rotation: The Mechanical Contractor shall be responsible to verify that the rotation of all 120 volt, single phase motors for mechanical equipment is in the correct direction prior to installation. The Electrical Contractor shall be responsible for correct rotation of all three-phase motors.
- J. Nameplates: A motor nameplate shall be securely affixed to each motor and shall clearly indicate the electrical data, horsepower, rpm, frequency, NEC code number, motor efficiency, class of insulation, winding material, and service factor.
- K. Energy Efficient Motors: Energy efficient motors shall be provided for motors which run "continuously" such as primary and secondary loop pump motors, cooling tower fan motors, outside air fan motors, toilet exhaust fan motors, and garage exhaust fan motors. Motor efficiency shall be based upon dynamometer testing per IEEE 112-E Test Standard, Method B, as set forth by NEMA MG 1-12.53a standard for efficiency testing and motor shall be labeled in accordance with NEMA MG1-12.53b. Motors shall be Baldor Super-E motors or an approved equal. Motors shall have a minimum efficiency as follows:
- | <u>Horsepower</u> | <u>Efficiency</u> |
|--------------------|-------------------|
| 5 - 20 H.P. | 92% |
| 25 - 40 H.P. | 94% |
| 50 H.P. and larger | 95% |
- L. Additional Requirements: All motors shall comply with applicable NEMA standards and shall be UL listed. Refer to the various equipment Sections of this Division for additional motor requirements.

2.02 Motor Controllers:

- A. General: All motor starters, controllers, and disconnect switches shall conform to requirements of Division 16 and additional requirements specified elsewhere in this Division or noted on the Drawings.
- B. Control and Interlock Wiring:
 - 1. Except as otherwise specified, the Mechanical Contractor shall provide low (or line where used as an alternate) voltage control and control interlock wiring required by the direct digital control system. Line voltage power wiring to master units of temperature control equipment shall be by the Electrical Contractor.
 - 2. Controls, control wiring, alarm contacts, and motorized dampers not required for the operation of the motor will be provided by the Mechanical Contractor.
 - 3. The Mechanical Contractor shall provide all thermostats required for equipment supplied under Division 15.
 - 4. Control of motorized louvers and interlocks with temperature control devices shall be provided by the Mechanical Contractor.
 - 5. The Electrical Contractor will provide power wiring to electric baseboard heaters and/or electric cabinet unit heaters.

Part 3 - Execution

3.01 General:

- A. Motors shall be leveled, set in true angular and concentric alignment with driven equipment, and bolted firmly to motor base, if not mounted on equipment. Motors factory-mounted on equipment shall be checked for alignment to driven equipment and mounting bolts shall be checked to ensure bolts are tightly fastened.
- B. Coordination: The Mechanical Contractor shall have the responsibility to provide adequate rough-in information to the Electrical Contractor. Any costs resulting from inadequate coordination, such as patching and refinishing of walls, shall be divided between the Electrical and Mechanical Contractors.
- C. Start-up: All motors installed shall have the amperage and voltage tested and recorded by the contractor responsible for start-up.

END OF SECTION 15030

Section 15041 – Interior Finish Office Design Parameters

Part 1 General

1.01 Related Documents:

- A. The conditions of the contract and applicable requirements of Division 1, and Section 15010, “Basic Mechanical Requirements”, govern this section.

1.02 Definition(s):

- A. Net Rentable Area-sqft. (NRSF): Shall mean the result of subtracting from the gross area of the floor, the area of the major vertical penetrations on that same floor. No deductions shall be made for columns and projections necessary to the building. Spaces outside the exterior walls, such as balconies, terraces, or corridors, are excluded. The building net rentable area shall equal the sum of all net rentable areas from each floor.
- B. Major Vertical Penetrations: Shall mean stairs, elevators shafts, flues, pipe shafts, vertical ducts, and their enclosing walls. Atria and light wells above the finished floor are included in this definition. Not included, are vertical penetrations built for the private use of a tenant. Structural columns, openings for vertical electric cable or telephone distribution, and openings for plumbing lines are not considered major vertical penetrations.
- C. Gross Building Area-sqft.(GSF): Shall mean the total constructed area of the building, excluding parking areas and loading docks (or portions of the same) outside the building line.
- D. Common Area Building Zone: The common area building zone is defined as the area common to all tenants. This area includes but is not limited to restrooms, janitor’s closets, electrical rooms, telecommunication closets, mechanical rooms, corridors, atrium and lobbies.
- E. Perimeter Building Zone: The perimeter building zone is defined as the area measured under the length of the perimeter of the building and 15 feet from the exterior column line.
- F. Interior Building Zone: The interior building zone is defined as the total net rentable square feet less the common area square feet and less the perimeter building zone square feet.

1.03 Description of Work:

- A. Work Included: The Work includes, but is not limited to, design and installation of the following systems, equipment, and services:
 - 1. Air Cooled Split Air Conditioning Systems:]
 - a. Provide and connect all ductwork, diffusers, insulation and controls to the existing air-cooled split air conditioning system. This scope of work shall include but not be limited to the design and installation of the, ductwork, insulation, filters, vibration isolation, fire dampers, grilles, registers, ceiling outlets, acoustic treatment of ducts, sound attenuating equipment (lined elbows and transfer ducts), controls and condensate drains.

- b. Where required to maintain design conditions and or specific tenant requirements, not covered under the initial shell building construction, relocate split systems to maintain required conditions. Provide new split systems where necessary to maintain conditions when existing equipment is not adequate to serve tenant load conditions.
- c. The installation of a new split system or relocation of existing shall include the connection of all associated ductwork, mechanical piping, insulation, vibration isolation, fire dampers, filters, grilles, registers, thermostat, and interface with existing temperature controls necessary to provide a fully functional split system.
- d. Split systems shall be installed above common area spaces, within the tenant space they serve. Split systems shall not be located above conference rooms, executive office space and/or other areas considered sensitive to noise.
- e. **Building Common Areas: [Where not provided in the base building construction]**
 - 1) Provide split systems for building common areas such as restrooms, atrium, elevator lobbies, service corridors, telecommunication closets, and the main building lobbies.
 - 2) The split system for public spaces shall consist of one split direct expansion air conditioning system per zone. Common area zone sizes can exceed the 1500 interior zone maximum. The split system unit cannot exceed 4 tons in sizes.
 - 3) Thermostat locations for units serving common areas are to be coordinated with VPTC Management Partners, LLC and the Architect. Thermostats are not to be installed in main entrance lobbies.
 - 4) Where split systems are installed to serve electric rooms or telecommunication closets, the thermostat is to be located within these rooms.
- f. **Split System Zone Sizing:**
 - 1) Provide one split system per perimeter net rentable building zone. A single perimeter zone shall be limited to a maximum of 800 square feet. No single perimeter building zone shall require more than 3 tons of cooling equipment capacity to maintain design conditions. The net rentable area (sq ft) shall be used in determining zone sizes.
 - 2) Provide one split system per interior net rentable building zone. A single interior zone shall be limited to a maximum of 1,500 square feet. No interior building zone shall require more than 3 tons of cooling equipment capacity to maintain design conditions. The net rentable area (sq ft) shall be used in determining zone sizes.
 - 3) The combined perimeter and interior zone size average for the total net rentable building sq ft shall not exceed 1000 sq ft.
 - 4) The interior and exterior zones shall not be served by the same split system. The Interior and exterior zones that have different functions (for example, a conference room and open office area) shall not be served by the same split ac system.
- g. The split direct expansion unit sizes shall be based on the peak load air conditioning and heating requirements of each zone with a minimum air circulation of 0.70 CFM

per square foot of conditioned space. Each split direct expansion unit shall have an electric, or electronic thermostat located in its respective zone to control temperature. Provide the thermostat and 40' of control wire coiled at the indoor unit.

- h. The locations of the condensing unit for the split systems are to be coordinated with VPTC Management Partners, LLC.
 - i. Refrigerant lines are to be installed in accordance with manufacturer's requirements and in a manner that will not cause premature failure of the compressor.
 - j. Each split system shall have an electronic thermostat located in its respective zone to control temperature. The thermostat shall be located in the space in an area that will best measure the actual room temperature. Coordinate with office furniture layout plan to locate thermostat in best location. Thermostats located near heat generating equipment, producing inaccurate results will need to be relocated by the installing contractor.
 - k. Where the ceiling space is utilized as a return air plenum, provide transfer ducts, fire dampers and or additional ductwork to ensure design airflow back to the unit.
 - l. Where required for excessive noise transmitted from ductwork and or split systems, sound attenuation shall be installed to maintain sound levels acceptable per ASHRAE Standards.
 - m. Building Pressure Control:
 - 1) The base building system air balance should be verified to ensure proper building positive pressure. This contractor shall request base building drawings and test and balance data to verify base building system balance. VPTC Management Partners, LLC shall be notified of any deficiency.
 - 2) All new split systems shall be provided with code required outside air and shall utilize the same concept for introduction of outside air as the base building systems. Verify the capacity of the base building outside air system prior to adding new systems. VPTC Management Partners, LLC shall be notified of any deficiency in system capacity.
 - 3) Any tenant system which results in addition of outside air or exhaust shall be integrated such that proper building positive pressure is maintained. Required base building system control or modification shall be included in the tenant design.
 - 4) Submit a summary of any addition or modification to the building air balance to VPTC Management Partners, LLC for review and approval.
2. **Packaged Roof Mounted Air Cooled Variable Air Volume Air Conditioning Systems:**
- a. Provide and connect all ductwork, diffusers, insulation and controls to existing terminal boxes including but not limited to hard duct branch lines, flexible ductwork, supply and return linear and square diffusers/grilles, thermostat and building controls.
 - b. Verify base building roof top equipment can maintain design conditions to the new and existing tenants, if additional building loads are added. Provide additional capacity when the base building rooftop systems cannot support additional building loads added as a result of the interior finish up-fit.

- c. Where required to maintain design conditions and or specific tenant requirements, not covered under initial construction, relocate terminal boxes to maintain required conditions. Locate boxes outside of perimeter offices for servicing and provide a designated box for each conference room or corner office. Provide new air terminal boxes with or without heat where necessary to maintain conditions when existing equipment is not adequate to serve tenant load conditions.
- d. The installation of a new terminal box (VAV with heat or without heat) or relocation of existing shall include the connection of all associated ductwork, insulation, vibration isolation, fire dampers, filters, grilles, registers, thermostat, and interface with existing temperature controls necessary to provide a fully functional terminal box. Terminal box installation or relocation shall match the base building standard for installation and materials.
- e. Fan powered terminal boxes shall be installed above common area spaces, within the tenant space they serve. Fan powered terminal boxes shall not be located above conference rooms, executive office space and/or other areas considered sensitive to noise.
- f. Fan powered terminal boxes installed in the building are to be relocated during interior finish, when they are located in conference rooms or executive office space. The relocated equipment shall be installed above common area spaces.
- g. Fan powered terminal boxes or VAV terminal boxes shall be installed to allow for manufacturer required maintenance access. Do not install any terminal box over a hard ceiling without the installation of adequately sized access panels.
- h. Where required for excessive noise transmitted via ductwork and or equipment, sound attenuation shall be installed to maintain sound levels acceptable per ASHRAE Standards.
- i. Where existing ventilation fan or ductwork system is not adequate to provide code required ventilation air, provide necessary equipment, ductwork, transfer grilles, balancing dampers and fire dampers to existing system to provide evenly distributed code required ventilation air.
- j. Where the ceiling space is utilized as a return air plenum, provide transfer ducts, fire dampers and or additional ductwork to ensure design airflow back to the unit.
- k. The air terminal unit sizes shall be based on the peak load air conditioning and heating requirements of each zone with a minimum air circulation of 0.7 CFM per net rentable square foot of conditioned space.
- l. Each air terminal units shall have an electronic thermostat located in its respective zone to control temperature. The thermostat shall be located in the space in an area that will best measure the actual room temperature. Coordinate the thermostat location with the office furniture and equipment layout plan to locate thermostat in best location. Thermostats located near heat generating equipment, producing inaccurate results will need to be relocated by the installing contractor.
- m. Common Areas: **[Where not provided in the base building construction]**
 - 1) Provide air terminal units for building common areas such as restrooms, atrium, elevator lobbies, service corridors, telecommunication closets, and the main building lobbies.

- 2) The basic system includes one air terminal unit per zone. A single zone for the common area can exceed 1500 square feet. The terminal unit serving the common areas shall not exceed 4 tons in cooling capacity.
 - 3) Where main entry lobbies, computer rooms, equipment rooms, elevator equipment rooms, electric rooms, and retail spaces are separated from typical office floors by multiple garage parking levels, the contractor may provide DX split system equipment for these remote areas in lieu of air terminal units.
 - 4) Thermostat locations for units serving common areas are to be coordinated with VPTC Management Partners, LLC and the Architect. Thermostats are not to be installed in main entrance lobbies.
 - 5) Where air terminal units are installed to serve electric rooms or telecommunication closets, the thermostat is to be located within these rooms.
- n. Air Terminal Unit Zone Sizing:
- 1) Provide one fan powered air terminal unit with electric re-heat per perimeter zone. A single perimeter zone shall be limited to a maximum of 800 square feet. No single perimeter building zone shall require more than 2,000 CFM cooling equipment capacity to maintain design conditions. The net rentable area (sq ft) shall be used in determining zone sizes.
 - 2) Provide one air terminal unit per interior zone. A single interior zone shall be limited to a maximum of 1,500 square feet. No single interior building zone shall require more than 2,000 CFM equipment capacity to maintain design conditions. The net rentable area (sq ft) shall be used in determining zone sizes.
 - 3) The combined perimeter and interior zone size average for the total net rentable building s area shall not exceed 1000 sq ft.
 - 4) Terminal unit sizes shall not exceed 2500 CFM.
 - 5) In tenant spaces with open office floor plans the interior zones of the VAV system can be larger than the 1500 sq ft maximum zone size. However, zone sizes cannot differ from the sizes noted above, without the review and approval of VPTC Management Partners, LLC. In all cases, the terminal box used to serve the larger zones cannot exceed 2500 CFM of equipment capacity.
 - 6) The interior and exterior zones shall not be served by the same air terminal units. Interior and exterior zones that have different functions (for example, a conference room and open office area) shall not be served by the same air terminal unit.
- o. Building Pressure Control:
- 1) The base building system air balance should be verified to ensure proper building positive pressure. This contractor shall request base building drawings and test and balance data to verify base building system balance. VPTC Management Partners, LLC shall be notified of any deficiency. Building pressure shall not exceed 0.035".
 - 2) All new terminal boxes shall be provided with an outside air to supply air ratio based on the base building rooftop unit system set-up. Additional outside air

shall be provided as required. An increase in the rooftop outside air ratio shall only be allowed if approved by VPTC Management Partners, LLC.

- 3) Any tenant system which results in addition of outside air or exhaust shall be integrated such that proper building positive pressure is maintained. Required base building system control or modification shall be included in the tenant design.
- 4) Submit a summary of any addition or modification to the building air balance to VPTC Management Partners, LLC for review and approval.

3. Toilet Exhaust:

- a. A toilet room exhaust air at each restroom shall be exhausted through sheet metal ductwork using exhaust fans located at the discharge of the duct. Maximum fan capacity per riser shall be 30,000 CFM.
- b. Toilet room exhaust shall be based on a minimum of 2 CFM per square foot of toilet room and in accordance with local code, whichever is greater. The exhaust should always maintain toilet rooms at a negative pressure in relation to the adjacent spaces.

4. Automatic Temperature Controls: [Applicable if the base building control system is a direct digital control system]

- a. All new or existing heating or cooling equipment installed, relocated or otherwise modified under the tenant finish scope of work shall be connected/reconnected to fully communicate with the base building temperature control system.
- b. The programming and graphics for the added heating and cooling equipment shall be added to the base building DDC system. Graphics and programming methods shall be consistent with the existing system.

5. Communication Rooms/Telephone Rooms: **[Where not provided in base building.]**

The main telephone/equipment room shall have a VAV box or split system for room conditioning. Communication and telephone rooms on the tenant floors shall be cooled but do not require dedicated equipment unless it is known that heat generating equipment will be concentrated in the space. VAV boxes serving tenant spaces shall not serve these rooms. **Tenant server room(s) that have a unit larger than 1 ton or run on a voltage higher than 120 volts will require an Emon Meter for usage monitoring. Coordinate this work with the Electrical Contractor.**

6. Plumbing: All interior finish plumbing systems shall be designed and installed, consistent with the materials and methods described within 15250, 15400, 15410, 15420, 15440

7. Fire Protection:

- a. All portions of building sprinkler design and construction shall meet NFPA requirements.
- b. Refer to specification section 15300 and 15041 for additional design requirements for fire protection.

1.04 Design Conditions:

- A. General: Components of the heating and air conditioning systems shall be designed and selected according to the following design conditions:
1. Outdoor Conditions:
 - a. Summer: 2005 ASHRAE .4% Design Criteria
 - b. Winter: 2005 ASHRAE 99.6% Design Criteria
 - c. For convenience, reference attached ASHRAE weather data for major metropolitan areas common to VPTC Management Partners, LLC. Reference the 2005 ASHRAE Fundamentals for locations not included.
 2. Indoor Conditions:
 - a. The following indoor conditions shall be maintained within all occupied spaces.
 - b. Summer: 74°F DB @ 60% RH (by system design without reheat)
 - c. Winter: 72°F DB (no humidity control) (without credit for internal gains or solar contribution) (humidification not required)
 - 1) Indoor conditions must be maintained within less than 1.5 °F mean deviation from temperature specified.
 - 2) The relative humidity requirement is a maximum condition and is not to be exceeded.
 - d. Elevator Machine Room: Actual requirements by the elevator equipment supplier shall establish this requirement.
 - e. Mechanical/Telephone/Electrical Spaces: Ventilate or condition to maintain space temperatures within the manufacturer's recommended limits. Electrical equipment and material ratings must be coordinated with the space conditions. Coordination with the Electrical Contractor is the responsibility of this Contractor.
 - f. Main Lobby: Provide positive pressure in the lobby to minimize infiltration.
 3. Lighting:
 - a. Office Areas 1.5 Watts/NRSF Fluorescent (All Areas) +0.5 Watts/NRSF Incandescent (For Exterior Offices)
 - b. Retail Shops 5 Watts/NRSF Total
 - c. Restaurants 5 Watts/NRSF Total
 - d. Public Lobbies 5 Watts/NRSF Total
 4. Equipment Heat Load:
 - a. Office Areas 2.0 Watt/NRSF
 - b. Retail 1.5 Watts/NRSF
 - c. Restaurants Seating 1 Watt/NRSF
 - d. Lobbies 0.5 Watts/NRSF

- e. Kitchen Per Kitchen Design
- 5. Occupancy (Use for calculating cooling load):
 - a. Office Areas 100 NRSF/person
 - b. Retail 40 NRSF/person
 - c. Restaurant 15 NRSF/person
 - d. Lobbies 33 NRSF/person
 - e. Kitchen 100 NRSF/person
- 6. Outside Air Ventilation: Provide outside air at the rates specified in ASHRAE 62.1-2004. At a minimum size equipment to accommodate normal office area functions based on the net rentable (NRSF) footage of the building. Air handling equipment shall be selected in the mid-range of its' maximum capacity.
- 7. Minimum Air Circulation:
 - a. All Occupied Spaces 0.70 CFM/NRSF
 - b. At a minimum supply registers are to be provided per every 210 sq ft. of usable space. Return grilles shall be provided per every 225 sq ft. of usable space.
- 8. Air Load Factors for HVAC Systems:
 - a. Duct heat gain * (Approximately 2% of unit capacity)
 - b. Fan motor * (Approximately 2%)
 - c. Duct leakage 5% (Downstream of heat pumps)
 - d. Contingency ** (Established at 5% for each heat pump)
 - e. Convert actual losses or loads to BTU/HR.
- 9. Window, Wall, and Roof Factors: Refer to the Architectural Drawings for area definitions, glass types, and roof details. Verify the shading coefficients of each glass type and U values of each wall, roof and floor with VPTC Management Partners, LLC.
- 10. Refer to specification section 15010.1.19 for Noise and Vibration design criteria.

Part 2 Products

Not applicable.

Part 3 Execution

3.01 System Layout:

- A. Good engineering practices shall be followed as outlined by professional organizations covering each area of work.

- B. Unitary equipment shall be sized and selected based on peak load conditions for the area which it serves.
- C. Unitary equipment (terminal units, zone dampers, roof top equipment) serving tenant spaces shall be sized, selected, and located to allow for separation of "like condition" spaces.
 - 1. Allow for 12'-0" exterior zone around the perimeter of the building.
 - a. Unitary equipment located above ceiling space intended to serve perimeter zones shall be placed at 15'-0" off the exterior column line.
 - 2. Dissimilar perimeter zones shall be separated by individual units. For example, (1) for North zone, (1) for South zone, etc.
- D. Supply air flow rates to the spaces shall be determined based on the sensible load in the space and the calculated supply air temperature and supply air flow rate shall be maintained by the unit.
- E. Noise levels must be taken into consideration in the placement of mechanical systems. Noise level requirements are specified in section 15010. Where noise criteria conditions cannot be met by standard installation, additional sound attenuation measures must be incorporated into the design of the mechanical system to maintain specified conditions.
- F. Where structurally possible, roof top equipment with air cooled condensing units shall be orientated with the fins on the condensers, facing the eastern exposure. This shall be done to minimize damage to the fins and coils from incoming storms.

END OF SECTION 15041

Section 15070 – Electric Heating Cable

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1 and Section 16010 "Basic Electrical Requirements", govern this Section.

1.02 Description of Work:

- A. General: The extent of electric heating cable work is as indicated by the requirements of this Section and as specified elsewhere in these Specifications. In general, electric heating cable shall be furnished and installed by the Mechanical and Plumbing Contractors in accordance with this Specification. Coordinate power wiring requirements for electric heating cable with the Electrical Contractor.
- B. Applications: Pipe heat tracing applications required for this project include, but are not limited to, the following:
 - 1. Provide pipe freeze protection heat tracing for all sanitary and storm piping, hydronic piping, domestic hot and cold water piping, and for sump pump and sewage ejector discharge piping which is exposed to outdoor temperatures. Heat tracing on wet fire protection systems is allowed only if acceptable to the local Fire Marshall.
- C. Types: The type of electric heating cable required for the project is self-limiting parallel resistance heat tracing cable.

1.03 Quality Assurance:

- A. Manufacturers: Provide products produced by one of the following:
 - 1. Chromalox Precision Heat and Control
 - 2. ESG Electrical Group
 - a. Easy Heat
 - b. Nelson Heat Trace
 - 3. Raychem, Division of Tyco Thermal Controls
 - 4. Thermon Manufacturing Company
- B. UL Standards: Electric heating cable shall conform to all applicable standards and shall be UL-labeled.

Part 2 Products

2.01 Materials and Components:

- A. Parallel Resistance Heat Tracing Cable: Provide parallel resistance heat tracing cable in the ratings required with non conductive thermoplastic material jacket as required.
- B. Electric Heating Cable Thermostat: Provide raintight NEMA 4 enclosure electric heating cable thermostat with temperature range from 0 to 90°F, single or double-pole, single-throw switch with heavy-duty 600 volt ac, 20 ampere contacts and as instructed by the cable manufacturer.
- C. Electric Heating Cable Accessories: Provide electric heating cable accessories, including heat transfer foil, stainless steel banding strips and fiberglass tape as instructed by the manufacturer for each particular application.

Part 3 Execution

3.01 Installation:

- A. General: Install electric heating cable in accordance with the manufacturer's written instructions, the applicable portions of the NEC and recognized industry practices to ensure that products serve the intended functions.
- B. Installation: Install electric heating cable where shown. The tracing system shall be designed to maintain a 40°F water temperature within the traced pipe, with an ambient temperature of 0°F.
- C. Thermostats: Install thermostat sensing bulb on opposite side of pipe from electric heating cable to provide pipe heat sensing control.
- D. Coordination: Coordinate installation of electric heating cable with piping, fittings, valves and insulation.
- E. Insulation: Pipe insulation over heating tape and cable is specified in Section 15250.
- F. Power Circuit: Connect electric heating cables only to circuits protected by ground fault circuit interrupters providing 30 ma equipment protection.

3.02 Testing:

- A. General: Test heating tape and cable to demonstrate proper operation. Repair or replace malfunctioning or damaged tape and cable. Retest to demonstrate proper operation.

END OF SECTION 15070

Section 15080 — Electronic Variable Speed Drives

Part 1 - General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Included: Furnish and mount all electronic variable speed drives (VSD) ready for wiring as required for equipment furnished under this division. All line voltage wiring shall be done by the Division 16 Contractor.
- B. The technical requirements of this section shall also apply to variable speed drives provided as part of factory packaged equipment.
- C. Types: The types of electronic variable speed drives required for the project include, but are not limited to variable frequency motor speed controllers.

1.03 Standards:

- A. Products shall be designed, manufactured, tested, and installed in compliance with the latest applicable standards of IEC, UL, ANSI, and NEMA.
- B. VSD design and construction shall comply with all applicable provisions of the National Electric Code.
- C. Each VSD shall comply with Part 15, Subpart J of FCC rules for Class A computing devices in the range of 7 to 30 MHz for conduction. FCC label of compliance shall be displayed on the VSD.

1.04 Quality Assurance:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
 - 1. Eaton Cutler-Hammer
 - 2. Square D
 - 3. Toshiba
 - 4. Yaskawa
- B. Factory Testing: To ensure quality, each VSD shall be subjected to the following factory tests:
 - 1. The integrated circuits shall undergo a 120-hour "burn-in" to test reliability. During the "burn-in" the temperature shall be cycled between 0 and 70°C.

2. The completed unit shall undergo a fully loaded 24-hour "burn-in" while serving a varying induction motor load. Test load shall vary between 50% and 100% of rated HP capacity and shall include a minimum of 12 hours at rated HP.
3. The unit shall be subject to a series of in-plant quality controlled inspections before approval for shipment from manufacturer's facilities.

1.05 Submittals:

- A. Shop drawing submittals shall include, but not be limited to, the following:
 1. Cut sheets of individual speed controllers with construction, dimensions, weights, ratings, voltage, poles, options, and all associated accessories clearly indicated.
 2. Wiring diagrams for the drive power, bypass, and control sections.
 3. A detailed description of drive operation and adjustable parameters.
 4. A detailed description of factory testing.
 5. Additional information as required in Section 15010.

1.06 Product Delivery, Storage and Handling:

- A. Store speed controllers in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle speed controllers carefully to avoid damage to material components, enclosure and finish.

Part 2 - Production

2.01 Electronic Variable Speed Drives:

- A. General: Provide electronic variable speed drives for control of standard or high-efficiency NEMA Design B induction motors as required for equipment
- B. Operation: Each variable speed drive shall convert available utility power to adjustable voltage/frequency, 3-phase, ac power for stepless motor control from 25 to 110% of motor 60 Hz speed.
 1. The variable speed drive (VSD) shall produce an adjustable ac voltage/frequency output for complete motor speed control. Speed control shall be stepless throughout the range under a variable torque load on a continuous basis. The VSD shall be automatically controlled by an external control signal.
 2. The VSD maximum output current rating shall be greater than or equal to the motor nameplate full load. The input power factor of the controller shall be 0.95 or greater under all speed and load conditions and the unit shall be rated for 100% operation at full rated current, voltage and frequency.
 3. The VSD shall contain a fused input power disconnect or circuit breaker with door interlock.

4. A dedicated line filter shall be provided at the input of the VSD to limit EMI from interference with vital electrical equipment if required for FCC compliance as specified in Paragraph 2.09/C/3.
- C. Components: Each controller shall include, but not be limited to an input rectifier, constant voltage dc link, filter, sine-weighted pulse width modulation inverter and accessory sections with each section modularized for ease of troubleshooting. Controller shall be protected with I²T fuses or circuit breakers per the manufacturer's design and specification. All components shall be factory mounted and wired on a dead-front, grounded, free-standing or wall-mounted minimum NEMA 1 enclosure arranged for top or bottom conduit entry. The free-standing enclosure shall be suitable for mounting on a steel platform or on a concrete housekeeping pad.
1. The controller enclosure shall be provided with the manufacturer's illustrated operating instructions and parts list mounted inside the enclosure door, manual speed control potentiometer or electronic manual control, three position mode selector switch (manual-off-auto), "power on" light, diagnostic/frequency display, auxiliary relays, and contacts for interlock and control wiring.
- D. Features: VSD features shall include, but not be limited to, the following:
1. Input Power: **[208] [480]** volts ac $\pm 10\%$, 60 Hz, ± 1.8 Hz. Input power factor shall be 0.95 or greater from full motor speed to zero speed for any motor load.
 2. Output Power: Three phase, 0-**[480] [208]** volts, 2-60 Hz.
 3. Ambient Temperatures: Operating: 0°C to 40°C (32°F to 104°F). Storage: -20°C to 60°C (-4°F to 140°F).
 4. Frequency Stability: Output frequency will be held to $\pm 0.1\%$ of maximum frequency regardless of load, $\pm 10\%$ input voltage change or temperature changes within the ambient specification.
 5. Disconnect: Locking type input disconnect switch with external operating handle.
 6. Bypass: Manual bypass that isolates the drive from the circuit and allows motor operation at full across-the-line speed. Bypass shall include motor contactor, drive isolation contactors, motor overload protection, fused control power transformer and front panel mounted bypass controls.
 7. Input Filter: Input line filter capable of protecting the electronics against transient voltage spikes or notches.
 8. Current Limit: To limit output current to 110% of that of the drive rating. The current limit shall be designed to function automatically to prevent overcurrent trip due to momentary overload conditions, allowing the drive to continue operation.
 9. Instantaneous Overcurrent Trip: To safely limit the output current in under 50 microseconds due to short circuit or severe overload conditions.
 10. Undervoltage Trip: To protect the drive due to non-momentary power or phase loss. The undervoltage trip will activate automatically when line voltage drops 15% below rated input voltage.
 11. Overvoltage Trip: To protect the drive due to voltage levels in excess of its rating. The overvoltage trip will activate automatically when the inverter bus in the controller exceeds 950 volts dc.

12. Ground Fault Protection: Fuseless electronic power protection for ground fault protection. Isolation transformers for ground fault protection are not acceptable. Ground fault shall not cause fuses to open.
13. Overload Protection: Electronic output overload protection shall be provided to eliminate the use of bimetallic overloads. The drive shall not be phase sequence sensitive. The overload protection shall also protect the motor when it is operated at full speed in the bypass mode.
14. Overtemperature Trip: To protect the drive from elevated temperatures in excess of its rating. An indicating light which begins flashing with 10°C of the trip point will be provided to alert the operator to the increasing temperature condition. When the overtemperature trip point is reached, this light will be continuously illuminated.
15. Automatic Reset/Restart: The drive shall be equipped such that a trip condition resulting from overcurrent, undervoltage, overvoltage or overtemperature shall be automatically reset, and the drive shall automatically restart upon removal, or correction of the causative condition. The number of reset/restart attempts for undervoltage, overvoltage, overtemperature and overcurrent shall be limited to five. If, in five attempts, a reset/restart is not successful, the drive shall shut down safely, requiring a manual restart. If, within five attempts, a successful reset/restart occurs, the Auto Reset/ Restart circuit will reset the attempts counted to zero after approximately 10 minutes of continuous operation.
16. Power Interruption: In the event that an input or output power contactor is opened or closed while the drive is activated, no damage to the drive shall result.
17. Short Circuit Protection: In the event of a phase-to-phase short circuit the drive shall be designed to shut down safely without component failure.
18. Sustained Power Loss: In the event of a sustained power loss, the drive shall be designed to shut down safely without component failure. Upon return of power, the system shall be designed to automatically return to normal operation.
19. Momentary Power Loss: In the event of a momentary power loss, the drive shall be designed to ride-through a power interruption up to five cycles and shut down safely without component failure. Upon a more extended momentary power loss, the system shall be designed to automatically return to normal operation upon return of power.
20. Stand Alone Operation: To facilitate start-up troubleshooting, the drive shall be designed to operate without a motor or any other equipment connected to the drive output.
21. Start/Stop Control: The drive may be started or stopped by any one of the following:
 - a. A contact closure rated 50 ma, 115 volt ac minimum.
 - b. Use of a motor starter or contactor in the input power line.
 - c. The speed control signal dropping below or rising above minimum.
 - d. An external 115 volt ac signal.
 - e. Operation of momentary start/stop switch or pushbuttons. The drive shall include built-in holding contacts for this purpose.
22. Speed Control: The drive will adjust the output frequency in proportion to a [0-10 volt dc analog] [4-20 ma dc analog] input.

23. Minimum and Maximum Speed Control: Adjustable minimum and maximum speed potentiometers for all speed signals. Minimum range shall be 0-80%, field set at 40%. Maximum range shall be 100-0%, field set at 100%.
24. Signal Gain and Offset: Adjustable signal gain (1:1 to 10:1 range) and offset (0-50% of input signal for all speed signals).
25. Inverted Signal: Inverted speed signal selector switch to invert the response to input speed signal.
26. Automatic Reversing: Reversing terminals to automatically reverse the rotation of the motor(s) shall be available for customer use if so desired. When a contact closure is made across these terminals, the motor shall decelerate from its operating speed to zero at the preset deceleration rate. Upon reaching zero, it shall reverse direction and accelerate to the set speed at the present acceleration rate.
27. Adjustable Accel/Decel: Independently adjustable acceleration and deceleration time potentiometers from 30-300 seconds, field set at 90 seconds.
28. Control Isolation: Low voltage logic and 115 volt control circuits shall be electrically isolated from the power circuits. Signal circuit common shall be grounded.
29. Control Adjustments: All control adjustments shall be made without the necessity of an extender board or specialized meters, and from front accessible controls.
30. Diagnostics: A diagnostic fault detection center shall be integral to each VSD, providing an indication of the following fault conditions:
 - a. External fault.
 - b. Processor line fault.
 - c. Low ac line voltage.
 - d. High ac line voltage.
 - e. Current overload.
 - f. High dc bus voltage.
 - g. VSD output fault.
31. Status Indication: Status indication of conditions described in Items 1 through 5 shall be provided. An SPDT contact for remote indication of Items 2 through 5 shall be provided. Additionally, status to show "Power On", "Zero Speed", and "Drive Enabled" shall be provided. All status indication shall be self-contained in the front panel of the unit and shall be duplicated for ease of troubleshooting on the inside of the unit.
32. Indicating Lights:
 - a. Power On: Lights any time input power is applied to the drive.
 - b. Zero Speed: Illuminates whenever the drive is at zero frequency.
 - c. Enabled: Lights to indicate that the drive has a start command.
 - d. Over Temperature: Begins flashing when the internal temperature of the drive is within 10°C of overheating. Upon reaching the overtemperature trip point, the light is continuously illuminated.

- e. Current Limit: Indicates that the Accel, Decel or Run Limit circuit is in operation.
 - f. Undervoltage: Indicates that an undervoltage trip has occurred.
 - g. Overvoltage: Indicates that an overvoltage trip has occurred.
 - h. Overcurrent: Indicates that the current rating of the drive has been exceeded and the overcurrent trip circuit has been activated.
33. External Alarm Contacts: A single pole, double throw contact rated 115 volt ac, 28 volt dc, 1 amp resistive, shall be available for external monitoring. Contact will change state when any trip condition has occurred.
34. Speed Reference Signal: A 0 to 5 volt dc signal shall be provided for customer use. This 0 to 5 volt dc signal shall vary in direct proportion to the drive speed.
35. User Interface: The VSD shall have the following door mounted user interface devices:
- a. "Power On" light.
 - b. Hand/Off/Auto (or equivalent) selector switch.
 - c. Manual speed potentiometer.
 - d. Digital Readout Frequency Meter/Diagnostic Display.
36. Cooling: The VSD shall be convection-cooled. Units requiring fan cooling are not acceptable. The unit shall have high temperature protection.
37. Control Power: A 115 volt ac, control power shall be available for customer use whenever drive input power is applied.
38. External Safeties: Fire alarm interface, safety and temperature control interlock terminals with door mounted "external fault" light.
39. Open Communication: The VFD shall be equipped with a factory installed open communications such as Modbus. The open communication will allow the DDC system to both push commands to the drive and pull information from the drive unit. All control points shall be available to the DDC system and the unit shall be completely configurable without the use of proprietary software.

E. System Operation:

- 1. Selector switch in the "off" position - the controller run circuit will be open and the system will not operate.
- 2. Selector switch in the "manual" position - the speeds of the motor will be controlled by the manual speed potentiometer.
- 3. Selector switch in the "auto" position - operation will be via the external control input signal with the output speed proportional to the input signal.

Part 3 - Execution

3.01 Installation of Electronic Variable Speed Drives:

- A. General: Install electronic variable speed drives where shown, in accordance with the manufacturer's written instructions, the applicable requirements of the NEC and the NECA's "Standard of Installation", and recognized industry practices to ensure that products serve the intended function.
- B. Supports: Provide all electronic variable speed drives with galvanized angle or other suitable supports where mounting on wall or other rigid surface is impractical. Drives shall not be supported by conduit alone. Where drives are mounted on equipment served, the drive shall not inhibit removal of any service panels or interfere with any required access areas. All drives shall be installed plumb and aligned in the plane of the wall in/on which they are installed.
- C. Coordination: The Division 15 Contractor shall coordinate electronic variable speed drive selection and installation including, but not limited to, the following:
 - 1. Coordinate power wiring to electronic variable speed drives and served motors with the Division 16 Contractor.
 - 2. Coordinate selection of variable speed drives and served motors to insure compatibility.
 - 3. Coordinate variable speed drive control interface with controls and sequence of operation specified in Section 15950, "Direct Digital Control Systems".

3.02 Start-up/Testing:

- A. Pre-energization Check: The Division 16 Contractor shall check electronic variable speed drive power wiring for continuity of circuits and for short circuits.
- B. Start-up Services: A representative of the variable speed drive manufacturer shall provide start-up services for each drive including, but not limited to, the following:
 - 1. Check out of drive control and power wiring.
 - 2. Start-up drive and demonstrate proper manual, automatic, and bypass operation.
 - 3. Adjust variable speed drive overload protection and other adjustable parameters to suit project requirements.
- C. Motor/Controller Coordination Documentation: Provide motor/controller coordination documents including, but not limited to, the following information in the operation and maintenance manuals.
 - 1. Motor size in horsepower.
 - 2. Motor full load amps.
 - 3. Motor efficiency.
 - 4. Motor service factor.
 - 5. Size and manufacturer's catalog number of electronic variable speed drives.
 - 6. Setting of electronic variable speed drive overload protection and other adjustable parameters.

- D. Motor Rotation: Verify that motor rotation is correct as connected. Where rotation must be changed, the Division 16 Contractor shall reconnect phase conductors to motor leads at motor junction box.

3.03 Training:

- A. General: A representative of the variable speed drive manufacturers shall provide for and present to the Owner, at no cost, a training and troubleshooting course at the owner's location. This course shall be comprised of 4 hours of instructions complete with visual aids, documentation, circuit diagrams, and hands-on training. This course is not to be construed as a sales meeting, but rather as a school to familiarize the owner with the care, troubleshooting, and servicing of the variable speed drives. The manufacturer's representative shall provide a list of recommended spare parts.

3.04 Identification:

- A. Refer to Section 15190 for nameplate requirements for all electronic variable speed drives.
- B. Each electronic variable speed drive shall have an internal wiring diagram on the inside of the drive cover and shall be labeled inside the cover to indicate the type, ampacity and horsepower rating of the unit.

END OF SECTION 15080

Section 15100 – Valves

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Provide valves as specified and indicated.

[EDIT THE FOLLOWING SECTIONS TO SUIT PROJECT]

1.03 Quality Assurance:

- A. Acceptable Manufacturers: The model numbers listed in the Specifications establish a level of quality and material. The following manufacturers are acceptable, subject to compliance with the requirements of these Specifications.

1. General Valves:
 - a. Crane Company
 - b. Grinnell
 - c. Jenkins Bros. Valves
 - d. Kennedy Valve
 - e. Nibco
 - f. Stockham Valves and Fittings
 - g. Walworth Company
2. Ball Valves:
 - a. Apollo
 - b. Jamesbury Corporation
 - c. Jenkins Bros. Valves
 - d. Nibco
 - e. Stockham Valves and Fittings
3. Backflow Preventers:
 - a. Febco Sales, Inc.
 - b. Watts Regulator Company

- c. Zurn Industries, Inc.; Wilkens-Regulator Division
- 4. Refrigerant Valves:
 - a. Henry Valve Company
 - b. Mueller Brass Company
 - c. Sporlan Valve Company
 - d. Superior Valve Company
- 5. Check Valves:
 - a. Clow Valve Company
 - b. Crane Company
 - c. Gruvlok
 - d. Jenkins Bros. Valves
 - e. Milwaukee
 - f. Muesco, Inc.
 - g. Nibco
 - h. Stockham
 - i. Victaulic
- 6. Butterfly Valves:
 - a. Apollo
 - b. Centerline
 - c. Demco
 - d. Grinnell
 - e. Gruvlok
 - f. Jamesbury Corporation
 - g. Jenkins Bros. Valves
 - h. Keystone
 - i. Nibco
 - j. Stockham Valves and Fittings
 - k. Victaulic

Part 2 Products

2.01 Materials:

- A. General: All valves shall be similar to numbers listed. All similar type and size valves shall be products of one manufacturer.
- B. Refrigerant Valves: Valves manufactured specifically for use in refrigerant systems shall be used in such systems.
- C. Butterfly Valves: All butterfly valves shall be full tapped and threaded lug type, manufacturer certified for bubble-tight, dead end shut off from either direction at design working pressure and temperature. Valves 2-1/2 through 5" in size shall have lever type operators. Valves 6" and larger shall have enclosed, self-locking worm gear type operators, waterproof, and factory-lubricated. Gear segment shall be manganese bronze or ductile iron with a steel or ductile iron worm and oil impregnated bronze bushings or worm shaft. Operator shall have built-in adjustable mechanical stops and position indicators. Valves used for balancing shall be certified suitable for continuous throttling service. Butterfly valves shall not be used on steam or high temperature hot water systems.
- D. Ball Valves: Valves shall be furnished with blowout-proof stems. Valves used for chilled water service shall be insulated as specified for the pipe in which the valve is installed. All ball valves shall be full-line size to prevent flow restriction through the ball.
- E. Gate Valves: All bronze gate valves shall have packing boxes with adequate depth to allow space for sufficient amounts of stem packing. Malleable iron handwheels and gland followers shall be furnished on all bronze gate valves. All gate valves shall have non-asbestos stem packing suitable for pressure and service. OS&Y and IBBM gate valves shall be furnished with a stem lubrication fitting on all sizes. All gate valves shall be designed to permit repacking while the valve is in line.

2.02 Valves:

- A. Valves for service at or less than 150 PSIG:
 - 1. Block (Stop) Valves: Ball valves 2" and smaller shall be red brass, cast bronze, or yellow forged bronze with brass, stainless steel, or bronze ball and stem, 150 psig nonshock WOG at 200°F, equal to Jenkins Fig. No. 900T. Valves 2-1/2" and larger shall be butterfly type, 200 psig nonshock WOG at 200°F, ANSI Class 150 with ductile iron lug body. The replaceable resilient elastomer seat shall be Buna N or EPDM. The disc shall be silicon or aluminum bronze and shaft shall be No. 316 or No. 416 stainless steel. Secondary O-ring seals shall be provided at the top and bottom of the upper and lower shafts to guarantee zero leakage to the shaft, equal to Jenkins Fig. No. 232EL/EG or No. 632E.
 - 2. Balancing Valves: Valves shall comply with the general requirements specified for block valves. Valves used for balancing shall have adjustable memory stops or position indicators. Valves 2" and smaller shall be equal to Jenkins Fig. No. 900TE. Valves 2-1/2" and larger shall be equal to Jenkins Fig. No. 232EL.
 - 3. Gate Valves: As a general rule, gate valves shall not be used for sizes 2-1/2" and smaller. If necessary, with prior approval from the Construction Manager, valves 2-1/2" and smaller shall be equal to Jenkins Fig. No. 47-U, 200 psig WOG bronze body with screwed bonnet and ends. Valves 3" and larger shall be equal to Jenkins Fig. No. 651-A, 200 psig WOG.

4. Globe Valves: Valves 2" and smaller shall be equal to Jenkins Fig. No. 546-P, bronze body, bronze rising stem, screw-in bonnet, renewable seat, and screwed or solder ends. Valves 2-1/2" and larger shall be Jenkins Fig. No. 613, 200 psig WOG, outside screw and yoke (OS&Y), iron body, bronze-trimmed, renewable seat, Pressure Class 125, with ANSI B16.1 flanged ends.
- B. Valves for Service Over 150 PSIG:
1. Block Stop Valves: Ball valves 2" and smaller shall be red brass cast bronze or yellow forged bronze with brass, stainless steel, or bronze ball and stem, 300 psig nonshock WOG at 200°F with Teflon packing and gaskets, equal to Jenkins Fig. No. 900T. Valves 2-1/2" and larger shall be 300 psig nonshock WOG, with Class 300 ANSI B16.5 flanges, full tapped and threaded cast steel lug body. Valves shall have 300 pounds body drilling and shall be suitable for service indicated on the Plans. Disc shall be cast steel and the shaft shall be No. 416 stainless steel. Secondary O-ring or gland seals at the top and bottom of the upper and lower shafts shall guarantee zero leakage to the shaft. Seals and backing rings shall be TFE or Viton. Seal retainer rings shall be No. 316 stainless steel, Dezurik No. 645.
 2. Balancing Valves: Valves shall comply with the general requirements specified for block valves. Valves used for balancing shall have adjustable memory stops or position indicators.
 3. Gate Valves: As a general rule, gate valves shall not be used for sizes 2-1/2" and smaller. If necessary, with prior approval from the Construction Manager, valves 2-1/2" and smaller shall be equal to Jenkins Fig. No. 270-U, 300 pounds WOG, bronze body, rising stem, with screwed bonnet and screwed ends. Valves 3" through 12" shall be equal to Jenkins Fig. No. 204, 500 pounds WOG, OS&Y valves with Class 250 ANSI B16.1 flanged ends, cast iron body and bronze trim.
 4. Globe Valves: Valves 2" and smaller shall be equal to Jenkins Fig. No. 556-P, 400 pounds WOG, bronze body and trim, rising stem, union bonnet, renewable seat, and screwed ends. Valves 2 1/2" through 8" shall be equal to Jenkins Fig. No. 923, 500 pounds WOG, iron body, bronze trim rising stem, OS&Y Class 250 ANSI B16.1 flanged ends.
- C. Check Valves: Chilled, hot, condenser, and domestic water pipes 2-1/2" and larger shall be, spring-loaded, quiet type. Valve nonshock pressure temperature rating shall be as specified for piping in which it is installed. Valve shall be full-threaded, lug body, or flanged body. Valves 2" and smaller shall be equal to Jenkins Fig. No. 92A. Threaded valves installed at pump discharge shall have its shaft perpendicular to the pump shaft. Valves located in pumped sewage pipes and in storm pipes shall be equal to Crane No. 383 outside weight, 200 pounds WOG, iron body, bronze trimmed, with swing check design.
- D. Valves for Water Make Up Connections: Valves 2" and smaller shall be equal to Jenkins Fig. No. 900T. Valves 2-1/2" and larger shall be equal to Jenkins Fig. No. 632B or No. 632E, butterfly valve operator furnished per Paragraph 2.01/C.
- E. Relief Valve: Temperature and pressure, self-closing, lever operated with thermo-bulb extension, 3/4", ANSI B2.1 taper thread male inlet connection, 210°F (98.8°C) and 125 psig setting, ANSI Z1.22, equal to Watts Regulator Company Type No. 40XL.
- F. Combination Pressure Reducing and Relief Valve for Make Up Water: Bell and Gossett Model Number 3, dual unit.

- G. Reduced Pressure Backflow Preventer: Backflow preventer shall be equal to Watts Regulator No. 909 Series, 2-1/2" and larger shall be provided with dual "Y" pattern spring-loaded check valves and independent relief valve located between checks. Backflow preventers shall be rated for pressure up to 150 psig working pressure at 140°F (60°C) and sized according to the maximum design flow.
- H. Domestic Water Pressure Reducing Valves: Watts Regulator 223S or Clayton 90G-01. Pressure and flow schedule as indicated on the Drawings.

Part 3 Execution

3.01 Installation:

- A. General: Except as otherwise indicated, comply with the following requirements.
- B. Ball Valves: Provide ball valves on branch service runout to each piece of terminal equipment, at each coil, and elsewhere as shown on the Drawings.
- C. Valve Stems: Install valves with stems pointed up, in the vertical position where possible, but in no case with stems pointed downward from a horizontal plane.
- D. Chain Operators: In central plant and in fan or mechanical rooms where chilled water and condenser water valves are installed over 8' above floor, provide chain operators.
- E. Swing Check Valves: Swing check valves shall be installed in horizontal piping only.
- F. Unions and Companion Flanges: Provide unions or companion flanges where required to facilitate dismantling of valves and equipment.
- G. Access Doors and Panels: Verify the location and quantity of access doors or panels required to provide full valve access.
- H. Backflow Preventer: All relief assemblies off of backflow prevention devices shall be piped to the nearest floor drain.
- I. Relief Valve: All relief valves including factory installed relief valves on boilers and domestic water heaters shall be piped to the nearest floor drain.

END OF SECTION 15100

Section 15135 - Meters and Gauges

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1 and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Provide meters, gauges, taps, and accessories as specified and indicated.

Part 2 Products

2.01 Gauges and Thermometers:

- A. Pressure Gauges: Gauges shall be Ashcroft, Ernst Gage, Marsh Instrument, Miljoco, Trerice, Weksler, Moeller, or Weiss with 4-1/2" dial face, cast aluminum case, stainless steel movement with Grade A phosphor bronze bourdon tube, Plexiglas dial cover and micrometer type calibration adjustment screw. Accuracy shall be ½% of full scale. Provide a gauge cock and pulsation dampener in pressure tube to gauge. Use liquid filled gauges, using duplex style (pressure & vacuum), where required. Graduation shall be one pound or less.
- B. Thermometers: Thermometers shall be Trerice, Weksler, Miljoco, Moeller, or Weiss solar-operated electronic type with high-impact ABS plastic case, minimum 3-1/2" union stem and complete with separable brass or stainless steel socket well. Thermometers shall be straight, incline or recline, selected and installed as best suited for ease in reading
- C. Range and Graduations: Gauges and thermometers shall be selected to give range and graduations best suited for quantities to be measured. Generally, gauges and thermometers shall be selected so that normal operating pressures and temperatures are neither more than 2/3 nor less than 1/2 of the range, scale division shall be 2°F or less. Typical ranges shall be:
 - 1. Heating Hot Water: 30 - 240 °F with 2 °F scale divisions.
 - 2. Chilled Water: 0 - 100 °F with 1 °F scale divisions.
 - 3. Condenser Water: 30-130°F with 1°F scale divisions.
 - 4. Domestic Hot Water (Dial Type): 30 - 240 °F with 2 °F scale divisions.
 - 5. Water: 0 - 100 psi with 1 pound scale divisions.
- D. Thermometer Wells: Thermometer wells shall be located so that the sensing bulb will give a true and correct reading. Thermometer wells shall be installed so as not to cause undue restriction in small piping. Where wells are located in pipe lines 1-1/2" and smaller, provide a section of pipe of such diameter that the net area of the pipe line will not be reduced by the thermometer well. Wells shall be filled with thermal grease and complete with caps and chains.

2.02 Pressure and Temperature Taps:

- A. Location: Provide pressure and temperature taps as required for start-up, balancing, and trouble shooting.
- B. Taps: Taps shall be 1/2" solid brass fittings which will receive either a pressure or temperature probe, with valve core of Nordel, and fitted with a color coded cap and gasket. Taps shall be "Pete's Plug" (Peterson Engineering Company, PO Box 217, Richardson, Texas 75080, 214/235-8393) or "Sisco P/T Plugs", (Sisco, PO Box 197, Riverton, N. J. 09077, 609/829-8686) No. 710, rated at 275°F and 1000 psig.
- C. Instruments: Furnish two each, No. 500 "Pete's Plug" pressure gauge adapters with four gauges and probes and four each 5" stem pocket thermometers: Two "Pete's Plug" or "Sisco P/T Plug" No. 601 with 25 to 125°F range for condenser water and two "Pete's Plug" No. 603 with zero to 220°F range for heating water.

2.03 Gauge Cocks:

- A. Locations: Gauge cocks to be used for test gauges shall be provided in the entering and leaving piping to equipment, coil, coil control valve, orifice metering flange, and at other locations required for balancing and start-up.
- B. Manufacturer: Gauge cocks shall be brass lever handle type equal to Crane No. 88 needle valves, or approved equal.

Part 3 Examination

3.01 Installation:

- A. General: Install meters and gauges in accordance with the manufacturer's written instructions and in locations indicated. Position meters and gauges so that they are easy to read standing on the floor and accessible for inspection and maintenance.
- B. Thermometers and gauges shall be selected so that normal operating conditions is located the middle of the gauge range.
- C. Pressure Gauge Locations: A gauge shall be installed in the following locations:
 - 1. To indicate the suction and discharge pressures of each pump
 - a. A single gauge valved to read either inlet or outlet pressure shall be acceptable at pumps so long as the low and high of the normal operating pressure do not fall outside of the upper or lower 1/2 of the range.
 - 2. At incoming city water pressure
 - 3. Downstream of domestic booster pump
 - 4. Downstream of each pressure reducing valve
 - 5. At each fire system riser
 - 6. Dry system air pressure

7. At inlet and outlet of each plate type heat exchanger
 - a. A single gauge valve to read either inlet or outlet pressure shall be acceptable at hat exchanger so long as the low and high of the normal operating pressure do not fall outside of the upper or lower $\frac{1}{2}$ of the range.
 8. At the inlet and outlet of each strainer/filter including at air separators and pump suction diffusers.
 9. Elsewhere as indicated or required for proper balancing and maintenance of the system.
- D. Thermometer Location: A thermometer shall be installed in the following locations:
1. In each supply and return main located at the central plant
 2. At inlet and outlet of each boiler, chiller, or cooling tower
 3. At the connections to each air handling unit coil
 4. At inlet and outlet of each heat exchanger
 5. Adjacent to each immersion controller
 6. Elsewhere as required for proper balancing and maintenance of the system

END OF SECTION 15135

Section 15140 –Hangers, Supports, and Anchors

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.
- B. Reference applicable project piping system specifications for additional support requirements.

1.02 Description of Work:

- A. Work Included: Provide hangers, supports, and required appurtenances as specified and indicated.

1.03 Quality Assurance:

- A. MSS Standard Compliance: Provide pipe hangers and supports of materials, design, and manufacture which comply with ANSI/MSS SP-58, SP-59, SP-89, and SP-90.
- B. Acceptable Manufacturers: The manufacturer specific model numbers listed herein establish a level of quality and material. The following manufacturers are acceptable subject to compliance with the requirements of this Specification:
 - 1. Anvil Corporation (formerly ITT Grinnel Corporation)
 - 2. Carpenter and Patterson, Inc.
 - 3. Central Iron Manufacturing Company
 - 4. Cooper B-line, Inc.
 - 5. Elcen Metal Products Co.
 - 6. Fee and Mason Mfg. Co.
 - 7. F & S Manufacturing Company.
 - 8. Michigan Hanger
 - 9. Persing & Co.
 - 10. PHD Manufacturing
 - 11. Powerstrut
 - 12. Thomas & Betts Superstrut

Part 2 Products

2.01 Pipe Hangers and Supports:

- A. General: Comply with local codes and standards for pipe and equipment support and anchorage.
- B. Materials: Pipe supports shall be of material that will prevent electrolytic action. Exterior pipe supports and supporting materials shall be galvanized finished with zinc-coated fasteners. Use a galvanizing repair finish of not less than 94 percent zinc dust by weight for reglazing exterior welds of ferrous metals.
- C. Inserts: Provide Grinnell No. 282 inserts for concrete construction.
- D. Piping in Single Runs: Provide Fee and Mason Fig. 239 or Grinnell No. 260 clevis hanger.
- E. Piping in Multiple Parallel Runs: Provide Grinnell No. 45 or No. 50 with Grinnell No. 137 U-bolt pipe clamps or structural channels or angles with U-bolt clamps, supported as trapeze hangers where multiple parallel runs of piping are shown. Select and size members for weights to be carried and span dimensions between supports.
- F. Hanger Rod: Provide hanger rods of required length at appropriate to handle piping loads and structure movements.
- G. Riser Clamps: Provide Fee and Mason Figure 241 riser clamps. Riser clamps for copper tube shall be copper-plated.
- H. Saddles and Shields:
 - 1. Saddles for Horizontal Insulated Piping Without Vapor Barrier: At each hanger or support on horizontal runs, provide Grinnell No. 160 or Fee and Mason Figure 171, 1710, 1712, or 172 saddles, as applicable. Shields as described below may be used instead of the saddles. Where dissimilar materials are used, provide dielectric separation. Carry insulation over the hanger and seal where hanger is sized for pipe.
 - 2. Shields for Horizontal Insulated Water Piping With Vapor Barrier: At each hanger or support for water piping, provide a half section of preformed 6 PCF density fiberglass or rigid calcium silicate, with jacket of adjacent insulation brought across unbroken, supported on semicircular 16 gauge shields. Shields for pipe 4" and smaller shall be 12" long; shields for pipe 5 to 8" shall be 18" long; and shields for larger pipe shall be 24" long.
- I. Piping on Roof: Roof mounted pipe supports are discouraged. If roof supports are necessary, installation methods must be approved by VPTC Management Partners, LLC and the Roofing Contractor.

2.02 Roof Supports:

- A. Large (over 6-inch diameter) gas piping or cooling water line supports:
 - 1. Shall be prefabricated system with bases to accommodate uni-strut tube frame as required to support number and size of piping to be supported.
 - a. C-Port CB-Series support with hanger accessory components, by Cooper B-Line, Inc., Highland, IL, (618) 654-2184.
 - b. Model 6-H with clevis hangers, by Miro Industries, Inc., Sandy, UT, (800) 768-6978.

- c. Model PSE with clevis hangers, by Portable Pipe Hangers, Inc., Houston, TX, (713) 672-5088.
- B. Medium (3-inch to 6-inch diameters) gas line or conduit line supports:
1. Gas line supports shall be prefabricated system with base to accommodate threaded rods and roller support:
 - a. C-Port CE-Series support with roller accessory components, by Cooper B-Line, Inc., Highland, IL, (618) 654-2184.
 - b. Model 5-RAH or 5-RAH-12 with roller, by Miro Industries, Inc., Sandy, UT, (800) 768-6978.
 - c. Model PPH-RB18 with roller, by Portable Pipe Hangers, Inc., Houston, TX, (713) 672-5088.
 2. Conduit line supports shall be prefabricated system with base to accommodate threaded rods and channel/strut support as required by number and size of lines:
 - a. C-Port CE-Series support by Cooper B-Line, Inc., Highland, IL, (618) 654-2184.
 - b. Model 16-Base Strut P, by Miro Industries, Inc., Sandy, UT, (800) 768-6978.
 - c. Model PP10 with Channel, by Portable Pipe Hangers, Inc., Houston, TX, (713) 672-5088.
- C. Small (less than 3-inch diameter) gas line pipe supports:
1. Shall be prefabricated system with base to accommodate threaded rods and roller support:
 - a. C-Port CR-Series support, by Cooper B-Line, Inc., Highland, IL, (618) 654-2184.
 - b. Model 3-RAH or 3-RAH-12, by Miro Industries, Inc., Sandy, UT, (800) 768-6978.
 - c. Model PP10 with Roller, by Portable Pipe Hangers, Inc., Houston, TX, (713) 672-5088.
 2. Shall be prefabricated system with base to accommodate threaded rods and channel/strut support with clevis hanger(s):
 - a. C-Port CE-Series support with hanger accessory components, by Cooper B-Line, Inc., Highland, IL, (618) 654-2184.
 - b. Model 2.5 SB-H, by Miro Industries, Inc., Sandy, UT, (800) 768-6978.
 - c. Model PP10 with Channel & Hanger, by Portable Pipe Hangers, Inc., Houston, TX, (713) 672-5088.
- D. Duct supports:
1. Shall be prefabricated system with bases to accommodate uni-strut tube frame as required to support exact ductwork sizes and equipment to be installed.
 - a. C-Port CS-Series support, by Cooper B-Line, Inc., Highland, IL, (618) 654-2184.
 - b. Model No. 8-DS, by Miro Industries, Inc., Sandy, UT, (800) 768-6978.

- c. Model PPH-D, by Portable Pipe Hangers, Inc., Houston, TX, (713) 672-5088.

Part 3 Execution

3.01 Installation:

- A. Independent Support: Support fire sprinkler and standpipe piping independently of other piping in accordance with NFPA-approved methods and local codes and standards.
- B. Provisions for Movement:
1. Movement: Install hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate the action of expansion joints, expansion loops, expansion bends, and similar units.
 2. Load Distribution: Install hangers and supports to evenly distribute weight and so piping live and dead loading and stresses from movement will not be transmitted to any pipe or connected piece of equipment. Pipe supports shall properly transmit the weight of the pipe and its contents to the building structure, or to independent posts, piers, or foundations. Piping shall be fully supported from hangers and supports prior to connection to equipment and/or flanges.
 3. Pipe Slopes: Install hangers and supports to provide the indicated pipe slopes so maximum pipe deflections allowed by ANSI B31 are not exceeded.
- C. Insulated Piping: Comply with the following installation requirements:
1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through the insulation; do not exceed pipe stresses allowed by ANSI B31.
 2. Shields: Where low-compressive-strength insulation or vapor barriers are indicated on cold, chilled, or heating water piping, install coated protective shields. For pipe 8" and over, install rigid calcium silicate insulation between saddles and pipe.
 3. Where insulation without vapor barrier is indicated, install protection saddles, or use hangers as indicated in Paragraph 2.01/G.1.
- D. Spacing: Hangers and supports shall be installed as required by the following table. Local code requirements shall override. Refer to MSS Standard SP-69 for applications not listed:

HANGER SPACING BY PIPING MATERIAL

<u>Nominal Pipe Size</u>	<u>Maximum Hanger Spacing</u>	<u>Minimum Rod Size</u>
Schedule 40 Steel		
≤1"	7'	1/4"
1-1/4"-1-1/2"	9'	3/8"
2"	10'	3/8"
2-1/2"	11'	3/8"
3"	12'	3/8"
4"	14'	1/2"
5-6"	17'	1/2"
8"	19'	5/8"
10"	20'	3/4"

12"	23'	7/8"
14"	25'	1"

Copper Tubing

≤3/4"	5'	1/4"
1"	6'	1/4"
1-1/4"-2"	8'	3/8"
2-1/2"	9'	3/8"
3"	10'	3/8"
4"	12'	1/2"

Lead and Oakum Cast Iron

All sizes	Maximum 5', except 10' spacing where 10' lengths of pipe are installed, located within 18" of joint.	1/2"
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Compression and Hubless Cast Iron

All sizes	Up to 4' section length - at every other joint; >4' pipe lengths - on each side of coupling, located within 18" of joint.	1/2"
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Schedule 40 PVC and ABS

≤2"	4'	1/4"
3-8"	4'	3/8"
≥10"	4'	1/2"

- E. Riser Supports: Vertical piping shall be secured at sufficiently close intervals to keep the pipe in alignment and carry the weight of the pipe and contents.
1. Cast iron soil pipe shall be supported at the base and at each story level, but in no case at intervals greater than 10'.
 2. Steel pipe shall be supported at the base and at not less than every other story level, but in no case at intervals greater than 25'.
 3. Copper tube shall be supported at each story level, but in no case at intervals greater than 10'.
 4. Plastic pipe shall be supported at mid point between floors and at ceiling to prevent movement, but in no case at intervals greater than 8'.
- F. Guides: Install pipe guides complying with the manufacturer's published product literature. Where not otherwise indicated, install pipe guides near expansion loops, expansion joints, and ball joints.
- G. Anchors: Install anchors at the proper locations to prevent stresses from exceeding those permitted by ANSI B31 and to prevent the transfer of loading and stresses to connected equipment. Anchors shall include vibration isolation in accordance with the pipe support system specified. Where the piping system is floating, the anchors shall be termed restraints or braces.

1. Where expansion compensators are indicated, install anchors in accordance with the expansion unit manufacturers written instructions, to limit movement of piping and forces to the maximums recommended by the manufacturer of each unit.
 2. Where not otherwise indicated, install anchors at the ends of principal pipe runs and at intermediate points in pipe runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.
- H. Leveling: Adjust hangers and supports and place grout as required under supports to bring piping to proper levels and elevations.
- I. Hangers: Refer to Section 15240, "Vibration Isolation", for additional information and support requirements. Pipe hangers made of wood, wire, or sheet iron shall not be permitted.

END OF SECTION 15140

Section 15170 – Mechanical Pumps

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Provide pumps as specified and indicated.
- B. Work of Other Sections:
 - 1. Refer to Division 16 for electrical connection work required in conjunction with pump motors (not work of this Section), controllers, and alarms.
 - 2. Refer to Section 15240, "Vibration Isolation", for materials required for isolation of pumps.
 - 3. Refer to Section 15250, "System Insulation", for piping and equipment thermal insulation work required in conjunction with pumps.
 - 4. Refer to Section 15510, "Mechanical Piping Systems", for flexible piping connections at pumps.

1.03 Quality Assurance:

- A. Manufacturers: Provide products by one of the following:
 - 1. Armstrong Pumps, Inc.
 - 2. Aurora Pump Company
 - 3. Bell and Gossett, ITT Division,
 - 4. Marshall Engineered Products Company
 - 5. Peerless Pump Company
 - 6. TACO Incorporated
 - 7. Wienman Pumps
- B. Electrical Standards: Provide electric motors and products which have been listed and labeled by Underwriters' Laboratories, Inc. (UL) and comply with National Electrical Manufacturers' Association (NEMA) standards.
- C. Certification, Pump Performance: Provide pumps whose performance, under specified conditions, is certified by the manufacturer.

Part 2 Products

[EDIT THE FOLLOWING SECTIONS TO SUIT PROJECT]

2.01 [Chilled, Condenser and Heating Hot Water Pumps:]

A. [Horizontal Split Case Pumps:]

1. General: Horizontal split case pumps, where used, shall have the capacities required for the application. Pump performance shall be shown on curves of pressure versus flow. Operating point shall be at a minimum efficiency of 75% and impeller diameter shall not materially exceed 85% of the maximum size that the casing will accept. Pump discharge velocities shall not exceed 12' per second for chilled water and heating water service. Total dynamic head shall be a maximum at no-flow and decrease from no-flow to design flow. Shut-off head shall be more than 110% of design head but less than 140% of design head. Pumps shall have hydraulically and dynamically balanced impellers. Pumps shall be free of flashing and cavitation at all flow rates from 25 to 125% of design flow under the suction conditions of the pump installation. The percent of maximum diameter shall be noted on the Shop Drawing submittal.
2. Features: Pumps shall have 300 psig minimum casings, enclosed double suction impellers, SAE 1045 steel shafts for packing gland pumps, stainless steel shafts for mechanical steel pumps, cast iron casing wearing rings, bronze impeller wearing rings, cast iron deflectors, stainless steel impeller key, coated fiber parting gasket, steel casing studs and bolts, and internal drilled passages to lantern rings. Mechanical seals shall be used on all chilled and heating water pumps. Packing gland seals, used on condenser water pumps, shall consist of five rings of graphite asbestos packing, bronze split glands, bronze lantern rings, brass gland clips, stainless swing bolts and nuts, and 500 Brinnell hardness stainless steel sleeves. A manually operated petcock shall be installed on the vent tapping on the top of the casing. Removal of the upper half of the pump casing shall allow removal of the rotating element without disconnecting the suction and discharge piping. Pump shall be provided with 125 lb flanged suction and discharge connections.
3. Performance: Pumps having motors larger than 10 HP shall be capacity tested after final assembly. Provide for each pump, a certified shop performance test curve indicating capacity, head, horsepower, and efficiency at flow rates from shutoff to 125% of design flow. When the pumps are shipped from the factory, the manufacturer shall transmit three copies of a certified letter stating that the pumps have been dynamically balanced, pressure tested, and capacity tested. The certified shop performance test curves shall accompany the certified letter. No pump shall be installed before its test data has been reviewed by the Design Engineer and VPTC Management Partners, LLC.
4. Seals: The mechanical seals shall be as manufactured by John Crane Company, Environamic Inc., Chesterton, or Durometallic Inc. and shall be suitable for the service specified:
 - a. Seals for stuffing box working pressures 150 psig and below shall be equal to John Crane Company Type 1 or Type 2.
 - b. Seals for stuffing box working pressures greater than 150 psig shall be equal to John Crane Company Type 1B.
 - c. After the pumps are in operation for 90 days, the Contractor shall check the seals and replace any that are defective.

5. Bearings: Pumps shall have grease-lubricated ball bearings, grease fittings, and relief plugs. Bearings shall have a minimum B-10 life of 40,000 hours minimum life below 200 psig suction pressure and 20,000 hours for suction pressures above 200 psig. Bearings shall be removable without removing the rotating element or dismantling the pump.
 6. Base: Base shall have cast iron or fabricated steel drip lip bases, coupling guard, provisions for grouting, anchor bolts, and collection of all seal leakage. The base shall have machined surfaces for the motor and pump mounting surfaces. Motor mounting shall permit horizontal adjustment. A threaded outlet of 3/4" minimum size shall be provided in the base at the pump end for field piping of drainage to drain. The base shall be of sufficient strength to prevent vibration, warping, or misalignment of the pump and motor when installed without grouting. The base shall be rigidly bolted to the concrete base. After final alignment, all pumps 25 HP and over shall have the pump and motor doweled to the base. In addition, the minimum requirements of the fabricated structural steel base shall be as follows:
 - a. Pumps with 20 HP and smaller motors shall have steel bases adequately stiffened as required to prevent "oil-canning".
 - b. Pumps with 25 HP and larger motors shall have bases constructed of structural shapes and formed steel section. The main structural member and formed steel sections shall have a depth of at least 1/2 the overall length of the base, but not less than 4". Standard or factory bases that do not meet this requirement shall be certified by the pump manufacturer to be constructed with sufficient strength to prevent vibration, warping, and misalignment of the pumps. The base shall be filled with concrete or grout after installation on the isolation base. Concrete and grout shall be provided by this Contractor.
 - 1) Grout-less bases by ITT Bell & Gossett may be installed on pumps with 25 HP and larger motors with prior approval from VPTC Management Partners, LLC.
 7. Couplings: Pumps shall have couplings using tapered split hubs and resilient torque transmitting members, not requiring shrink fit or press fit to pump or motor shaft. Align shafts of motors and pumps within recommended tolerances by the manufacturer, and in the presence of the manufacturer's representative. Provide a certified report for each pump
 8. Motors: Pumps shall have drip-proof motors suitable for electrical service with a service factor of 1.15 and a rated temperature rise of 104°F (40°C). Motors and pumps shall be factory-mounted and aligned on bases. Motors shall not overload when operation is from 0 to 125% of design flow on the pump characteristic curve.
- B. [End Suction Base-mounted Pumps:]
1. General: End suction, vertical split case, base-mounted pumps, where used, shall have the capacities required by the application. Pump performance shall be shown on curves of pressure versus flow. Operating point shall be at a minimum efficiency of 70% and impeller diameters shall not materially exceed 85% of the maximum size the pump casing will accept. Where pump curve has a "hump", operating point shall fall below the head at the shutoff point. Impellers shall be enclosed and shall be hydraulically and dynamically balanced.
 2. Features: Pump shall have casings of 300 psi duty gray cast iron, shafts shall be high tensile carbon steel, and bearings shall be grease-lubricated bronze sleeve or ball bearings. Provide pumps with John Crane (see Paragraph 2.01/A.4) mechanical seals,

Alemite type grease fittings. A manually operated petcock shall be installed on the vent tapping on the top of the casing. Pump shall be provided with 125 lb flanged suction and discharge connections.

3. Design: Pumps and motors shall be individually mounted on pump base so that bearing assembly and impeller can be removed without disconnecting piping, removing pump casing, or removing motor. Pump shaft shall be supported from removable bearing assembly bolted to pump casing and shall be connected to pump motors by flexible coupling.
4. Motors: Pump motors shall be suitable for the electrical characteristics available. Motors shall be open drip-proof with service factor of 1.15, rated for a 104°F (40°C) temperature rise. Motors shall not overload when operation is at any point of the pump characteristic curve.
5. Bearings: Bearings shall be grease lubricated and shall have a minimum B-10 life of 20,000 hours.

2.02 Circulating Pumps:

- A. General: In-line circulating pumps shall be cast iron body construction of the size, type, and capacity required by the application. Pumps shall be fitted with a hydraulically and dynamically balanced, bronze enclosed type impeller with mechanical seal. Mechanical seal shall be Type 1 or Type 2 material, Code BP-1D1 as manufactured by John Crane Company or an approved equal, suitable for service specified. Motor shall have a maximum speed of 1750 rpm. Pumps, casings, flanges, and seals shall be suitable for operation with the working pressures and temperatures required. The working pressure applies to the entire pump assembly.

2.03 Pump Accessories:

- A. Pump Suction Diffusers:
 1. Cast-iron body, with threaded connections for 2 inch and smaller, flanged connections for 2-1/2 inch and larger; 175 psig working pressure, 300 deg F maximum operating temperature; and complete with the following features:
 - a. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
 - b. Cylinder strainer with 3/16 inch diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.
 - c. Disposable fine mesh strainer to fit over cylinder strainer.
 - d. Permanent magnet, located in flow stream, removable for cleaning.
 - e. Adjustable foot support, designed to carry weight of suction piping.
 - f. Blowdown tapping in bottom; gage tapping in side.

Part 3 Execution

3.01 Inspection:

- A. General: Installer shall examine the bases upon which and conditions under which pumps are to be installed and notify Contractor in writing of conditions detrimental to proper and

timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.02 Installation of Pumps:

- A. General: Install pumps in accordance with manufacturer's written instructions and recognized industry practices to ensure that pumps comply with requirements and serve intended purposes. Comply with NEMA standards and requirements of NEC.
- B. Alignment: Align shafts of motors and pumps to manufacturer's tolerances in the presence of the manufacturer's representative. A certified report shall be submitted by the manufacturer for each pump.
- C. Vibration Isolation: Install units on vibration mounts and isolation bases as required to prevent vibration transfer to building structure.
- D. Lubrication: All pumps installed are to be lubricated per the manufacturers' recommendations.
- E. Pumps for chilled water service shall be provided with a factory installed welded seam drain pan under the pump. The drain pan outlet shall be piped to the nearest floor drain.

3.03 Pump Accessories:

- A. Install suction diffusers on all end-suction centrifugal pump's suction line in lieu of reducing elbow, entrance pipe, and pressure gage outlet. Install on pump suction inlet, adjust foot support to carry weight of suction piping. Install nipple and shutoff valve in blowdown connection.
- B. Install flexible connectors on all pump on the equipment side of the shut-off valves. Piping and pumps flanges shall be aligned to prevent forces in flexible connectors and in compliance with manufacturer's requirements.

3.04 Electrical Connections:

- A. Grounding: Provide positive electrical pump and motor grounding in accordance with applicable requirements of the NEC.

3.05 Field Quality Control:

- A. Field Test: Upon completion of pump installation and after motor has been energized from normal power source, bleed air from pump casing and test pump to demonstrate compliance with requirements. When possible, field-correct malfunctioning units then retest to demonstrate compliance. Replace units that cannot be satisfactorily corrected.
- B. Start-up: During start-up and system flushing, fine-mesh construction strainers shall be installed. After start-up and completion of piping system flush, construction strainers are to be removed and final strainer sets installed.

3.06 Horizontal Split Case and End Suction Pumps:

- A. Erection: Pumps shall be leveled, then bolted and grouted to pump bases. Piping shall be arranged so that pump cases are not subjected to any piping forces. Contractor shall check for proper angular and concentric alignment of pumps and motors before pumps are

operated. Run full sized drain connections from drip lip bases of horizontal split case pumps to nearest floor drain.

END OF SECTION 15170

Section 15190 – Mechanical Identification

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, “General Requirements”, and Section 15010, “Basic Mechanical Requirements”, govern this Section.

1.02 Description of Work:

- A. Work Included: Identification of mechanical equipment shall consist of equipment labeling, ductwork marking, pipe marking, and valve tagging as specified hereinafter.
1. In general, all equipment shall be labeled. This shall include all central plant, air handling or air conditioning equipment, and other similar and miscellaneous equipment.
 2. Pipe markings shall be applied to all piping.
 3. Each valve shall be identified with a stamped tag. Valves and tagging shall be scheduled typewritten on 8 ½” x 11” paper, tabulating valve number, piping system, system abbreviation, location of valve (Room or area), and service (e.g. – 2nd Floor North Domestic Hot Water). The valve schedule shall be submitted to VPTC Management Partners, LLC for approval prior to ordering or installing valve tags. See Section 15010, “Basic Mechanical Requirements” for information and requirements regarding Operation and Maintenance Manuals.
 4. Labels, tags, and markers shall comply with ANSI A13.1 and other applicable state and local standards for lettering size, colors, and length of color field.
 5. Equipment and device identification specified in other sections shall be provided as a part of those requirements.

Part 2 Products

2.01 Equipment Labeling:

- A. Equipment labeling shall be one of the following, unless noted or specified otherwise:
1. Permanently attached engraved brass or plastic laminated signs with 1” high lettering. Signs on exterior equipment shall be brass.
 2. Stencil painted identification, 2” high letters, with standard fiberboard stencils and standard black (or other appropriate color) exterior stencil enamel.

2.02 Ductwork Markings:

- A. Ductwork marking shall be color-coded, laminated plastic pressure sensitive vinyl tape, 2 ½” width, 3 mils minimum thickness. Identification shall include service (e.g. – Supply, return, exhaust, outside air), as well as the direction of air flow.

2.03 Pipe Markings:

- A. On piping less than 6" diameter, install plastic semi-rigid snap-on type, manufacturer's standard pre-printed color-coded pipe markers extending fully around the pipe and insulation or pressure-sensitive vinyl pipe markers similar to the above. Pipe markings can also be applied with the stick type backing in lieu of the semi-rigid snap-on-type.
- B. On piping and insulation 6" and greater diameter, full band as specified above or strip-type markers fastened to the pipe or insulation with laminated or bonded application or by color-coded plastic tape not less than 1 1/2" wide, full circle at both ends of the marker. Pipe markings can also be applied with the stick type backing in lieu of the semi-rigid snap-on-type.
- C. Arrows for direction of flow provided integral with the pipe marker or separate at each marker.

2.04 Valve Tags:

- A. Valve tags shall be polished brass or plastic laminate with solid brass S hook and chain. Tags shall be stamped or engraved with the appropriate abbreviation for the type of service (e.g. – CHW, HW), as approved by VPTC Management Partners, LLC, as well as the designated valve number.
- B. A valve schedule is to be provided to VPTC Management Partners, LLC. For each page of valve schedules, a glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.

2.05 Approved Manufacturers:

- A. Labels, markings, and tags shall be manufactured by W.H. Brady, Brimar Industries, Seton Name Plate Corp, Allen-Bailey Tag & Label, or Industrial Safety & Supply.

Part 3 Execution

3.01 General:

- A. Identification labeling, marking, and tagging shall be applied after insulation and painting has been completed.
- B. Coordinate names, abbreviations, and other designations used in mechanical identification work with corresponding designations shown, specified, or scheduled on drawings. Prior to ordering any labels, markings, or tags, obtain the approval of VPTC Management Partners, LLC regarding names, abbreviations, etc.
- C. The Plumbing, HVAC, and Fire Suppression Contractors shall coordinate labeling, marking, and tagging to ensure consistent and coordinated identification. In existing buildings, utilize similar names, abbreviations, and other designations that are currently in use to remain consistent with existing identification.
- D. Equipment labeling shall consist of unit designation as shown on the drawings. Exhaust fan labeling shall also indicate service or the room or area of service.

- E. Pipe and ductwork markers shall be placed on piping and ductwork on 25' centers in mechanical rooms and concealed spaces. In locations where piping and ductwork is exposed, place markers on 50' centers. Flow directional arrows should be marked on the piping at taps from the main and riser.
- F. Valve tags shall be placed on each valve except those intended for isolation of individual heat pumps or terminal units (e.g. - VAV boxes, fan coil units, unit heaters, etc.). Valve tag schedules shall be prepared as specified hereinbefore. Copies of one schedule shall be laminated in clear plastic and placed where directed by the Owner. Other sets shall be included in the Operating and Maintenance Manuals.

END OF SECTION 15190

Section 15240 – Vibration Isolation

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1 and Section 15010, "Basic Mechanical Requirements", govern this Section.
- B. The requirements of this section shall apply to all other Division 15 equipment sections.
- C. Refer to Section 15510 – Mechanical Piping Systems, for flexible piping connections associated with vibration isolation.
- D. Refer to Section 15891 – Ductwork, for flexible ductwork connections associated with vibration isolation.

1.02 Description of Work:

- A. Work Included: Provide and install vibration isolation products as specified and indicated, including the following:
 - 1. Vibration control bases:
 - a. Support isolation for motor-driven mechanical equipment
 - b. Inertia base frames in conjunction with equipment isolation
 - 2. Vibration control mounts:
 - a. Support isolation of air-handling housings
 - 3. Vibration control hangers:
 - a. Support isolation of piping
 - b. Support isolation for piping risers
 - 4. Horizontal Thrust Restraints:
 - 5. Rooftop Isolation Curbs:

1.03 Quality Assurance:

- A. General: Except as otherwise indicated, obtain support isolation units from a single manufacturer.
- B. Supervision: Manufacturer shall provide technical supervision of the installation of support isolation units produced by him and of associated inertia bases.
- C. Manufacturers: Provide vibration isolation support units manufactured by one of the following or an approved equal:
 - 1. Kinetics Noise Control, Inc.

2. Mason Industries, Inc.
3. Vibration Eliminator Co., Inc.
4. The VMC Group
 - a. Amber/Booth Co.
 - b. Korfund Dynamics Corporation
 - c. Vibrations Mounting and Controls, Inc.

Part 2 Products

[EDIT THE FOLLOWING TO SUIT PROJECT]

2.01 General Application Requirements:

- A. General: Comply with the minimum static deflections recommended by the American Society of Heating, Refrigerating and Air Conditioning Engineers, including the definitions of critical and non-critical locations, for the selection and application of vibration isolation materials and units as indicated.
 1. General: Except as otherwise indicated, select vibrations control products in accordance with ASHRAE Handbook, 2003 Applications Volume, Chapter 47 "Sound and Vibration Control", Table 42.
- B. Manufacturer's Recommendations: Except as otherwise indicated, comply with manufacturer's instructions for selection and application of vibration isolation materials and units.
- C. "Outdoor" isolators shall be protected as follows: Steel parts other than springs shall be dry galvanized; springs and hardware shall be cadmium plated or otherwise suitably coated to resist corrosion.
- D. Vertical limit restraints shall be built-in to all units, rails and bases which support equipment whose weight varies with the addition or removal of large amounts of water, such as cooling towers, chillers, boilers and for equipment installed on rooftops subject to wind loads.

2.02 Vibration Control Bases:

- A. TYPE 1: Structural steel bases:
 1. Vibration isolator manufacturer shall furnish integral structural steel bases. Bases shall be rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases which may be "T" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells.
 2. All perimeter members shall be beams with a minimum depth equal to 1/10th of the longest dimension of the base. Beam depth need not exceed 14" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer.

3. Height saving brackets shall be employed in all mounting locations to provide a base clearance of one inch.
- B. TYPE 2: Isolation rail bases:
1. Bases shall be structural beam sections with welded on isolator support brackets and pre-located and drilled anchor bolt holes or skids, and shall be designed and supplied by the isolation materials manufacturer.
 2. Beam sections shall not be structurally connected to each other.
 3. Minimum section depth of each member shall be equal to 8% of the longest span between supporting isolators, or as shown on the drawings or indicated on the project documents.
 4. Isolator support brackets shall be welded to the structural beams as required to obtain the lowest mounting height for the supported equipment.
- C. TYPE 3: Concrete filled inertia bases:
1. Vibration isolator manufacturer shall furnish rectangular structural beam or channel concrete forms for floating foundations. Bases shall be engineered for a minimum base to equipment weight ratio of 2: 1.
 2. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity
 3. In general, bases shall be a minimum of 1/12th of the longest dimension of the base, but not less than 6".
 4. Forms shall include minimum concrete reinforcement consisting of half-inch bars or angles welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom, or additional steel as is required by the structural conditions
 5. Forms shall be furnished with drilled steel members with sleeves welded below the holes to receive equipment anchor bolts where the anchor bolts fall in concrete locations.
 6. Height saving brackets shall be employed in all mounting locations to maintain a 1" clearance below the base.

2.03 Vibration Control Mounts:

- A. TYPE 1: Neoprene pads:
1. Isolation pads shall be high quality elastomer suitable for minimum 120 psi loading.
 2. Pads shall be installed in multiple layers with galvanized steel shims between layers as required by loading. Single thickness pads of higher psi rating may be substituted for multiple layer pads with the approval of the Architect/Engineer.
- B. TYPE 2: Neoprene mounts:
1. Double deflection neoprene mountings shall have a minimum static deflection of 0.35".

2. All metal surfaces shall be neoprene covered to avoid corrosion and have friction pads both top and bottom so they need not be bolted to the floor. Bolt holes shall be provided for these areas where bolting is required.
3. On equipment such as small vent sets and close-coupled pumps, steel rails shall be used above the mountings to compensate for the overhang.

C. TYPE 3: Spring mounts:

1. Spring type isolators shall be free standing and laterally stable without any housing and complete with 1/4" neoprene acoustical friction pads between the baseplate and the support.
2. All mountings shall have leveling bolts that must be rigidly bolted to the equipment.
3. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load.
4. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.

D. TYPE 4: Restrained spring mounts:

1. Equipment with operating weight different from installed weight, and equipment subject to wind loads shall be mounted on TYPE 3 Spring Mounts with integral housing as described herein.
2. Housing shall include vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection of cooling tower mounts and shall be located between the supporting steel and roof or the grillage and dunnage as shown on the drawings. The installed and operating heights shall be the same.
3. A minimum clearance of 1/2" shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operations.

2.04 Vibration Control Hangers:

A. TYPE 1: Spring hangers for pipe:

1. Vibration hangers shall contain a steel spring and 0.3" deflection neoprene element in series.
2. The neoprene element shall be molded with a rod isolation bushing that passes through the hanger box.
3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the hole and short circuiting the spring.
4. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.
5. Submittals shall include a scale drawing of the hanger showing the 30° swing capability.

B. TYPE 2: Pre-compressed Spring hangers for pipe:

1. Vibration hangers shall be as described for TYPE 1, but shall be pre-compressed to the rated deflection so as to keep the piping or equipment at a fixed elevation during the installation.
 2. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load.
 3. Deflection shall be clearly indicated by means of a scale.
- C. TYPE 3: Spring hangers for ductwork:
1. Vibration hangers shall contain a steel spring located in a neoprene cup manufactured with a grommet to prevent short-circuiting of the hanger rod.
 2. The cup shall contain a steel washer designed to properly distribute the load on the neoprene and prevent its extrusion.
 3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the hole and short-circuiting the spring.
 4. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.
 5. Hangers shall be provided with an eyebolt on the spring end and provision to attach the housing to the flat iron duct straps.
 6. Submittals shall include a scale drawing of the hanger showing the 30° capability.

2.05 Horizontal Thrust Restraints:

- A. Air handling equipment shall be protected against excessive displacement which might result from high air thrusts in relation to the equipment weight.
- B. The horizontal thrust restraint shall consist of a spring element in series with a neoprene pad as specified for TYPE 1 spring hanger and with the same deflection as specified for the mountings or hangers under the unit.
- C. The spring element shall be contained within a steel frame and designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4" movement at start and stop.
- D. The assembly shall be furnished with one rod and angle brackets for attachment to both the equipment and ductwork or the equipment and the structure.
- E. Horizontal restraints shall be attached at the centerline of thrust and symmetrically on either side of the unit.

2.06 Rooftop Equipment Isolation Curbs:

- A. Curb mounted rooftop equipment shall be mounted on vibration isolation bases that fit over the roof curb and under the isolated equipment.
- B. The extruded aluminum top member shall overlap the bottom member to provide water run-off independent of the seal.

- C. The aluminum members shall house cadmium-plated springs having a 1" minimum deflection with 50% additional travel to solid.
- D. Spring diameters shall be no less than 0.8 of the spring height at rated load.
- E. Wind resistance shall be provided by means of resilient snubbers in the corners with a minimum clearance of 1/4" so as not to interfere with the spring action except in high winds.
- F. The weather seal shall consist of continuous closed cell sponge materials both above and below the base and a waterproof flexible ductwork EPDM connection joining the outside perimeter of the aluminum members.
- G. Foam or other contact seals are unacceptable at the spring cavity closure. Caulking shall be kept to a minimum.

2.07 Isolator Applications:

- A. Isolation requirements for equipment on grade supported slabs, and on suspended concrete slabs of steel frame, concrete frame, and flat slab construction shall be based on the following tables. Isolation requirements for equipment on suspended lightweight construction such as bar joist shall be based on the table with twice the actual span, or as otherwise detailed or recommended by the isolator manufacturer for the duty.

B. EQUIPMENT ON GRADE SUPPORTED SLAB

EQUIPMENT	BASE	MOUNT	DEFLECTION
ITEM	TYPE	TYPE	INCHES
Reciprocating Refrigerant Compressor	3	3	0.75
Reciprocating Chiller	None	2	0.25
Reciprocating Condensing Unit	None	2	0.25
Packaged Centrifugal Chiller	None	1	0.25
Base Mounted Air Compressor	3	3	0.75
Close coupled pumps 10 Hp and up	1 or 2	3	0.75
Frame Mounted, Flexible Coupled Pumps 10 through 125 Hp	None	3	0.25
Cooling Towers and Closed Circuit Coolers	None	3	0.25
Axial Fans, Tubular Fans, and Fan Heads through 22 in. dia.	1 or 2 if req'd	2	0.25
Axial Fans, Tubular Fans and Fan Heads 24 in, dia. and over:			
Up to 300 RPM	1 or 2	3	Note 1
Over 300 RPM	1 or 2	3	0.75
Centrifugal Fans and Vent Sets Up to 22 in. dia.	1 or 2 if req'd	2	0.25
Centrifugal Fans and Vent Sets 24 in. dia. and over-Up to 50 Hp:			
Up to 300 RPM	1 or 2	3	Note 1
301 to 500 RPM	1 or 2	3	1.50
Centrifugal Fans and Vent Sets 24 in. dia. and over-Over 50 Hp:			
Up to 300 RPM	1 or 2	3	Note 1
Over 300 RPM	1 or 2	3	0.75
Packaged Air Handling Units	none	3	0.75

Note1: Deflection =250,000/ (RPM)²

C. EQUIPMENT ON SUSPENDED SLAB - MAX 20 FT. SPAN

EQUIPMENT	BASE	MOUNT	DEFLECTION
ITEM	TYPE	TYPE	INCHES
Reciprocating Refrigerant Compressor	3	3	0.75
Reciprocating Chiller	None	4	0.75
Reciprocating Condensing Unit	None	4	0.75
Packaged Centrifugal Chiller	None	4	0.75
Base Mounted Air Compressor	3	3	0.75
Close Coupled Pumps through 7.5 HP	1 or 2	3	0.75
Close Coupled Pumps 10 Hp and over	3	3	0.75
Frame Mounted, Flexible Coupled Pumps 10 Hp through 125 Hp	3	3	0.75
Cooling Towers and Closed Circuit Fluid Coolers			
Up to 300 RPM	none	4	Note 1
301 to 500 RPM	none	4	2.50
501 RPM and over	none	4	0.75
Axial Fans, Tubular Fans, and Fan Heads through 22 in. dia.	1 or 2 if req'd	3	0.75
Axial Fans, Tubular Fans, and Fan Heads 24 in. dia. and over			
Up to 300 RPM	3	3	Note 1
Over 300 RPM	3	3	1.50
Centrifugal Fans and Vent Sets Up to 22 in. dia.	1 or 2 if req'd	3	0.75
Centrifugal Fans and Vent Sets 24 in. dia. and over-Up to 50 HP			
Up to 300 RPM	3	3	Note 1
301 to 500 RPM	3	3	1.50
Over 500 RPM	3	3	0.75
Centrifugal Fans and Vent Sets 24 in. dia. and over-Over 50 HP			
Up to 300 RPM	3	3	1.50
Over 300 RPM	3	3	0.75
Packaged Air Handling Units	None	3	0.75

Note1: Deflection =250,000/(RPM)²

D. EQUIPMENT ON SUSPENDED SLAB - MAX 30 FT. SPAN

EQUIPMENT	BASE	MOUNT	DEFLECTION
ITEM	TYPE	TYPE	INCHES
Reciprocating Refrigerant Compressor			
Reciprocating Chiller	None	4	1.50
Reciprocating Condensing Unit	None	4	1.50
Packaged Centrifugal Chiller	None	4	1.50
Base Mounted Air Compressor	3	3	1.50
Close Coupled Pumps through 7.5 HP	1 or 2	3	0.75
Close Coupled Pumps 10 Hp and over	3	3	1.50
Frame Mounted, Flexible Coupled Pumps 10 Hp through 125 Hp	3	3	1.50
Cooling Towers and Closed Circuit Fluid Coolers			
Up to 300 RPM	none	4	Note 1
301 to 500 RPM	none	4	2.50
501 RPM and over	none	4	1.50
Axial Fans, Tubular Fans, and Fan Heads through 22 in. dia.	1 or 2 if req'd	3	0.75
Axial Fans, Tubular Fans, and Fan Heads 24 in. dia. and over			
Up to 300 RPM	3	3	Note 1
Over 300 RPM	3	3	2.50
Centrifugal Fans and Vent Sets Up to 22 in. dia.	1 or 2 if req'd	3	0.75
Centrifugal Fans and Vent Sets 24 in. dia. and over-Up to 50 HP			
Up to 300 RPM	3	3	Note 1
301 to 500 RPM	3	3	1.50
Over 500 RPM	3	3	0.75
Centrifugal Fans and Vent Sets 24 in. dia. and over-Over 50 HP			
Up to 300 RPM	3	3	2.50
301 to 500 RPM	3	3	2.50
Over 500 RPM	3	3	1.50
Packaged Air Handling Units	None	3	1.50

Note1: Deflection =250,000/(RPM)²

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E. EQUIPMENT ON SUSPENDED SLAB - MAX 40 FT. SPAN

EQUIPMENT	BASE	MOUNT	DEFLECTION
ITEM	TYPE	TYPE	INCHES
Reciprocating Refrigerant Compressor	3	3	1.50
Reciprocating Chiller	None	4	2.50
Reciprocating Condensing Unit	None	4	2.50
Packaged Centrifugal Chiller			
Base Mounted Air Compressor	3	3	1.50
Close Coupled Pumps through 7.5 HP	1 or 2	3	0.75
Close Coupled Pumps 10 Hp and over	3	3	1.50
Frame Mounted, Flexible Coupled Pumps 10 Hp through 125 Hp	3	3	2.50
Cooling Towers and Closed Circuit Fluid Coolers			
Up to 300 RPM	none	4	Note 1
301 to 500 RPM	none	4	2.50
501 RPM and over	none	4	1.50
Axial Fans, Tubular Fans, and Fan Heads through 22 in. dia.	1 or 2 if req'd	3	0.75
Axial Fans, Tubular Fans, and Fan Heads 24 in. dia. and over			
Up to 300 RPM	3	3	Note 1
Over 300 RPM	3	3	2.50
Centrifugal Fans and Vent Sets Up to 22 in. dia.	1 or 2 if req'd	3	0.75
Centrifugal Fans and Vent Sets 24 in. dia. and over-Up to 50 HP			
Up to 300 RPM	3	3	Note 1
301 to 500 RPM	3	3	2.50
Over 500 RPM	3	3	1.50
Centrifugal Fans and Vent Sets 24 in. dia. and over-Over 50 HP			
Up to 300 RPM	3	3	2.50
301 to 500 RPM	3	3	2.50
Over 500 RPM	3	3	2.50
Packaged Air Handling Units	None	3	1.50

Note1: Deflection =250,000/(RPM)²

F. EQUIPMENT ON SUSPENDED SLAB - MAX 50 FT. SPAN

EQUIPMENT	BASE	MOUNT	DEFLECTION
ITEM	TYPE	TYPE	INCHES
Reciprocating Refrigerant Compressor	3	3	2.50
Reciprocating Chiller	None	4	2.50
Reciprocating Condensing Unit	None	4	2.50
Packaged Centrifugal Chiller	None	4	1.50
Base Mounted Air Compressor	3	3	2.50
Close Coupled Pumps through 7.5 HP	1 or 2	3	0.75
Close Coupled Pumps 10 Hp and over	3	3	1.50
Frame Mounted, Flexible Coupled Pumps 10 Hp through 125 Hp	3	3	2.50
Cooling Towers and Closed Circuit Fluid Coolers			
Up to 300 RPM	none	4	Note 1
301 to 500 RPM	none	4	3.50
501 RPM and over	none	4	2.50
Axial Fans, Tubular Fans, and Fan Heads through 22 in. dia.	1 or 2 if req'd	3	1.50
Axial Fans, Tubular Fans, and Fan Heads 24 in. dia. and over			
Up to 300 RPM	3	3	Note 1
Over 300 RPM	3	3	2.50
Centrifugal Fans and Vent Sets Up to 22 in. dia.	1 or 2 if req'd	3	0.75
Centrifugal Fans and Vent Sets 24 in. dia. and over-Up to 50 HP			
Up to 300 RPM	3	3	Note 1
301 to 500 RPM	3	3	2.50
Over 500 RPM	3	3	2.50
Centrifugal Fans and Vent Sets 24 in. dia. and over-Over 50 HP			
Up to 300 RPM	3	3	Note 1
301 to 500 RPM	3	3	3.50
Over 500 RPM	3	3	2.50
Packaged Air Handling Units	None	3	1.50

Note1: Deflection =250,000/(RPM)²

2.08 Vibration control bases:

- A. For hydronic pumps, provide concrete inertia bases with structural steel pouring forms sized and reinforced as required for the intended service. Size bases to support the piping elbow supports and furnish with Type RSW recessed spring isolators properly sized for one-inch static deflection. Mount springs on concrete bases 3-1/2" high. Inertia base is not required for pumps installed on slabs on grade.

2.09 Vibration control mounts:

- A. Design and coordinate the structural supports with the Structural Engineer. Isolator housing to be hot-dipped galvanized springs to be neoprene-coated. Provide tie-down adjustment to prevent excessive movement when tower is drained. Provide vibration isolator rails or point isolators as required by the tower manufacturer.

2.10 Vibration control hangers:

- A. For suspended fans, isolate with not less than four combination spring and rubber-in-shear vibration isolators.
- B. Water source heat pumps shall be isolated with hanger and vibration isolation kit supplied by unit manufacturer or a vibration isolation manufacturer.
- C. All ductwork spring deflection shall be a minimum of 0.75 inches.
- D. Isolate fan coils and unit heaters with not less than four combination spring and rubber "in-shear" vibration isolators.

2.11 Flexible Piping Connectors:

- A. All piping over 1 inch in diameter shall be isolated at mechanical equipment room walls.
- B. Isolate supply and return piping to the cooling tower with flexible piping connectors.
- C. Isolate supply and return piping to each pump with braided metal hose connectors between pump and valve.

2.12 Horizontal Thrust Restraints:

- A. For air handling equipment, install thrust restraints as indicated, and wherever thrust exceeds 10% of equipment weight.

2.13 Rooftop Isolation Curbs:

- A. Provide housed spring type isolators with vertical limit stops.

2.14 Flexible Ductwork Connections to Equipment:

- A. Install flexible connections between sheet metal ductwork and equipment or fan collar. Locate as close to fan as possible. Isolate the duct system from the equipment by at least 1".

Part 3 Execution

3.01 Examination of Related Work:

- A. Examination and Reporting: Installer of vibration isolation work shall observe the installation of other work related to and connected to vibration isolation work. After completion of other related work (but before equipment start-up), he shall furnish a written report to the Contractor, with a copy to VPTC Management Partners, LLC, listing observed inadequacies for proper operation and performance of vibration isolation work.
- B. Correction and Start-up: Do not start-up equipment until inadequacies have been corrected in a manner acceptable to the vibration isolation Installer.

3.02 Equal Loading:

- A. General: All isolation devices shall be selected for uniform static deflections according to distribution of weight. Equipment installed on vibration isolating mountings shall be level after load is applied. Spring isolators with coils touching during equipment start-up or operation will not be acceptable.

3.03 Installation:

- A. General: Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration control materials and units.
- B. Remove space blocks and similar devices intended for temporary support during installation.
- C. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points.
- D. Flexible Pipe Connectors: Install on equipment side of shutoff valves, horizontally and parallel to equipment shafts wherever possible.
- E. All piping and equipment shall be installed and ready for operation (i.e. filled with water, etc.) prior to installation of flexible piping connection. Alignment of piping and equipment shall be such that flexible connections are not over extended and compressed from weight of piping, fittings, etc.

END OF SECTION 15240

Section 15250 – System Insulation

Part 1 General

1.01 Description:

- A. Furnish and install thermal insulation materials, coverings and accessories for mechanical piping, equipment and ductwork systems as specified herein. Extent of mechanical insulation work required by this Section shall be as indicated on drawings, schedules and by requirements of this Section.

1.02 Insulation Schedule:

A. Piping:

1. Type A – Fiberglass with white kraft paper fire retardant. (See Part 2 – Products)
 - a. Heating hot water
 - b. Domestic cold water, hot water and hot water return
 - c. Storm drain lines at roof deck from drain body to vertical riser
2. Type B – Black, closed cell flexible foam insulation. (See Part 2 – Products)
 - a. Refrigerant piping
 - b. Condensate drain lines
 - c. Note: Type B insulation shall not be used for domestic cold and hot water piping.
3. Type C – (Exterior Piping Applications) Polyisocyanurate with glass fiber wrap and PVC or metal jacket. (See Part 2 – Products)
 - a. Chilled water
 - b. Condensing water systems when used for waterside system economizing or in geothermal applications
 - c. Exterior domestic hot and cold water piping
 - d. Exterior make up water piping

B. Equipment:

1. Type D(H) - Semi-rigid fibrous glass board. (See Part 2 – Products)
 - a. Hot water tanks not factory insulated
 - b. Heating hot water air separators
2. Type D(C) - Closed cell flexible foam insulation. (See Part 2 – Products)
 - a. Roof drain bodies

- 1) Insulate all roof drain bodies at the roof deck.
 - b. Chilled water air separators or condenser water separators when used for waterside system economizer
 - c. Chilled water pump bodies or condenser water pump bodies when used for waterside system economizer
 3. Type E - Calcium silicate block insulation. (See Part 2 – Products)
 - a. Emergency generator exhaust piping and muffler; 4" thickness
- C. Ductwork Systems:
1. Type F – Fiberglass wrap with aluminum foil jacket. (See Part 2 – Products)
 - a. High, medium and low pressure ductwork
 2. Type G – Duct liner – Glass fiber coated with black fire resistant and microbial resistant coating. (See Part 2 – Products)
 - a. High, medium and low pressure ductwork when used for sound attenuation or if ductwork is exposed.
 - b. Low pressure return boot
 - c. Transfer ducts
- D. Insulation Installation Exceptions:
1. Exhaust ductwork, stairwell pressurization and dedicated smoke evacuation ductwork shall not be insulated, unless otherwise noted.
 2. Exposed ductwork shall be internally lined.
 3. The first 25 feet of supply ductwork downstream of rooftop or floor mounted air handling units shall be internally lined with Type G insulation for high frequency acoustical attenuation purposes.
 4. The first 10 feet of supply ductwork (low pressure) downstream of heat pumps, VAV terminals and fan-powered terminals shall be internally lined with Type G insulation for acoustical attenuation purposes.
 5. Return ductwork within 25 feet of floor-mounted air handling units or rooftop units shall be internally lined with Type G for high frequency acoustical attenuation purposes.
 6. At the contractor's option and with the approval of VPTC Management Partners, LLC Construction, medium and low pressure supply ductwork insulation may be omitted in return air plenums if not required by local codes (including energy codes). If accepted, a minimum of 2°F of duct temperature rise shall be applied in calculating supply airflows to the space.
 7. Selection of insulation thickness shall be in compliance with all local codes and local energy codes.
 8. All piping exposed to outdoors shall be insulated. Coordinate insulation with heat trace cable and controls.

1.03 Quality Assurance:

- A. All insulation, jacket and adhesive shall have a fire and smoke hazard ratings as tested under ASTM E-84, NFPA 255, and UL 723 not exceeding:
1. Flame Spread: 25
 2. Fuel Contributed: 50
 3. Smoke Developed: 50

1.04 Submittals:

- A. Provide submittal data on all insulation types to be installed in accordance with Section 15010.

1.05 Definitions:

- A. The term “plenum” shall mean a ceiling space or mechanical room used for the transfer of conditioned return and/or outside air.

1.06 Manufacturers:

- A. The model numbers listed in the Specification establishes a level of quality and material. The following manufacturers are acceptable subject to compliance with the requirements of these Specifications:
1. armacell engineered foams
 2. CertainTeed Corporation
 3. Dow Building Materials
 4. Knauf Insulation
 5. Johns-Manville
 6. Owens-Corning Fiberglass Corporation
 7. Pittsburgh Corning
 8. Rubatex International, LLC

Part 2 Products

2.01 Piping Insulation:

- A. Type A (Fiberglass, indoor):
1. One piece glass fiber, rigid molded sectional pipe covering with factory applied aluminum foil and white craft paper flame retardant vapor barrier jacket, conforming to ASTM C547, Class II, Mineral Fiber Preformed Pipe Insulation.
 2. Conductivity (k) equals approximately 0.23 (BTU/HR., SF., Degree F, IN) at 75 °F mean temperature.

3. Encase pipe fittings with one-piece pre-molded PVC fitting covers, fastened as per manufacturer's recommendations.
 - a. Under pre-molded PVC fitting coverings, wrap two separate layers of blanket insulation to provide same thickness and density as adjacent pipe covering.
 - b. Mitered segments of pipe insulation are also acceptable under PVC fitting covers when installing fiberglass insulation.
 4. Approved manufacturer's trade names:
 - a. Johns-Manville Corp. - "Micro-Lok 650-AP-T"
 - b. Owens Corning Fiberglass Corp. - "One Piece" 25 ASJ/SSL"
 - c. Other equal by listed manufacturer
- B. Type B (Closed Cell, indoor):
1. Closed cell, flexible foamed plastic conforming to ASTM C534, "Preformed Flexible Elastomeric Cellular Thermal Insulation in Tubular Form." Insulation shall be 6 lb/sf density suitable for a temperature range from –40 degrees F to 220 degrees F.
 2. Conductivity (k) equals approximately 0.28 (BTUHR., SF., Degree F, IN) at 75 °F mean temperature.
 3. Pipe insulation shall be applied in a continuous length and shall not be longitudinally slit.
 4. Approved manufacturers and trade names:
 - a. armacell engineered foams "Armaflex".
 - b. Rubatex
 - c. Other equal by listed manufacturer
- C. Type C (Polyisocyanurate, outdoor):
1. Prefabricated 2 lb./cu.ft. density polyisocyanurate insulation with waterproof mastic and glass fiber jacket finished with an aluminum jacket with waterproof silicone caulk joints.
 2. Conductivity (k) equals approximately 0.14 (BTUHR., SF., degrees F, IN) at 75 °F.
 3. Insulation shall be applied per manufacturer's recommendations. Joint sealants and coatings shall be as approved by the insulation manufacturer for the intended application and service temperature range.
 4. Jacketing shall be an all service jacket with 1 mil. aluminum foil on pipe insulation and FSK jacket on board stock applied by the manufacturer to ASTM C-1136. Jacket shall have integral flap for sealing joint.
 5. Approved manufacturers and trade names:
 - a. Dow Building Materials Trymer 9501
 - b. Other equal by listed manufacturer

2.02 Equipment Insulation:

A. Type D (Hot) (Fiberglass board for Hot Equipment):

1. Semi-rigid intermediate service fibrous glass board for operating temperatures greater than 850 degrees F.
2. Conductivity (k) equals approximately 0.23 (BTU/HR., SF., degrees F, IN) at 75 °F mean temperature. Minimum density of 2.75 lb / cu ft.
3. Approved manufacturers and trade names:
 - a. CertainTeed - " 850 Fiberglass Insulation Board"
 - b. Johns-Manville Corp. - "1000 series Spin Glass"
 - c. Owens Corning - "Intermediate Service Board"
 - d. Other equal by listed manufacturer

B. Type D (Cold) (Foamed Plastic for Cold Equipment):

1. Foamed plastic sheet suitable for operating temperatures between –40 degrees F and 22-degrees F.
2. Density shall be 6 lb/sfConductivity (k) equals approximately 0.287 (BTU/HR., SF., Degree F, IN) at 75 °F mean temperature.
3. Approved manufacturers and trade names:
 - a. armacell engineered foams "Armaflex"
 - b. Rubatex
 - c. Other equal by listed manufacturer

C. Type E:

1. Calcium silicate block conforming to ASTM C 553, Type I (1200 degrees F. max), asbestos free.
2. Conductivity (k) equals approximately 0.42 (BTU-IN/HR., SF., degree F) per inch thickness at 200 °F.
3. Approved manufacturers and trade names:
 - a. Calislite
 - b. Pabco Insulation - "Super Caltemp"
 - c. Other equal by listed manufacturer

2.03 Ductwork Insulation:

A. Type F:

1. Duct insulation shall be minimum 2" thick, minimum 3/4 lb. density fiberglass

- a. At locations with the International Energy Code, refer to Tables 6.8.2A and B for minimum duct insulation thickness.
2. Conductivity (k) equals approximately 0.24 (BTUHR., SF., degrees F, IN) at 75 °F mean temperature.
3. Integral UL rated vapor barrier of:
 - a. Aluminum foil reinforced with fiberglass scrim laminated to 30-lb. kraft paper.
 - b. Class I white vinyl 0.004 inch thick, where specified.
4. Approved Manufacturers and Trade Names
 - a. Certain Standard - "Universal"
 - b. Manville Corp. - "Microlite"
 - c. Owens Corning - "All Service Duct Wrap"
 - d. Other equal by listed manufacturer

2.04 Type G - Duct Liner:

1. ASTM C1071, Type II, Grade 2, R-6, 1" thickness, 1.5 lb. density for low pressure ductwork and 3.0 lb density for medium pressure ductwork, bonded mat of glass fiber coated with black fire resistant and microbial resistant coating, complying with TMS AHC-101. Moisture adsorption shall not be greater than 0.5% moisture by volume when exposed to moisture-laden air at 120°F and 96% RH, per ASTM C553. Insulation shall be Schuller "Permacote Linacoustic" R-300, "Aeroflex Ductliner" as manufactured by Owens Corning Fiberglass Corp. or "Ultralite with Certa-Edge" by CertainTeed Corp. or equal by Knauf Fiberglass.
2. Duct liner adhesive shall comply with ASTM C916 "Specifications for Adhesives for Duct Thermal Insulation".
3. Liner Fasteners: Mechanical or weld secured fasteners for duct liner where finish of duct is not exposed. For exposed ductwork, except in mechanical rooms, provide adhesively secured fasteners. Position fasteners are recommended by SMACNA. The interior duct insulation shall be applied as recommended by the manufacturer including proper adhesive and adhered clips. Clip spacing shall not exceed 8" on center perpendicular to air flow and shall not exceed 12" on center in the direction of air flow.
4. All joints of the insulation shall have edges buttered with sealant, and shall be tightly buffed. Apply a brush coat of sealant at all joints on the surface of the duct liner extending at least 1" on each side of joint. Provide metal nosing on all exposed edges of duct liner at fire dampers, control dampers, fan discharges, etc.
5. Minimum Sound Absorption coefficients shall be per ASTM-E 477:

2.05 Exterior Protection:

A. Metal Jacket:

1. Smooth aluminum jacket 0.016 inch thick with integral polykraft or poly-surlyn moisture barrier. Provide banded locking joints with field applied silicone weatherproof sealant.

2. Approved manufacturers:
 - a. RPR Products, Inc.
 - b. Childers Products Co.
 - c. Manville Corp.
 - d. Pabco Division of A.J. Gerrard & Company
- B. Foil/Film Facing for ductwork
 1. Jacketing shall be a five-ply laminated foil/film facing for exterior applications. Product shall be a five-ply laminate alternating layers of aluminum foil (core and outer layers) with two layers of polyester film. Substrate thickness shall be not less than 3.0 mils and the adhesive thickness shall be not less than 2.0 mils.
 2. Product shall be coated with Venture Tape's cold weather acrylic, pressure sensitive adhesive system suitable for application in below freezing temperatures.
 3. Laminate construction shall be highly puncture, tear resistant and flame retardant. Product shall be suitable for application between -10°F and 248°F. Product shall be suitable for use at temperatures up to 300°F.
 4. All joints shall be sealed with manufacturer's recommended joint tape.
 5. Product shall carry a ten year warranty

Part 3 - Execution

3.01 Piping Insulation General Requirements:

- A. Preparation:
 1. Do not apply insulation until piping has been leak tested.
 2. All surfaces to be insulated shall be dry and free of loose scale, rust, dirt, oil or water.
- B. Application:
 1. Insulation shall be installed in a smooth, clean workmanlike manner. Joints shall be tight and finished smooth without fishmouths.
 2. Insulation shall fit tightly against the surface to which it is applied to prevent air circulation between the insulation and the pipe or equipment to which it is applied.
 3. Insulation applied to cold piping or equipment shall be completely vapor sealed, free of pinholes or other openings.
 4. Do not use wet insulation materials.
 5. All longitudinal joints on vertical pipe runs shall be staggered.
 6. Apply insulation so as to permit expansion or contraction of pipelines without causing damage to insulation or surface finish.

7. Do not apply mastic or adhesive until all previous applications of mastic and adhesives have thoroughly dried.
8. No bands or staples shall be provided on covering.
9. The adhesive used in connection with all covering work shall contain an approved vermin and rodent-proof ingredient.
10. Provide 24-gauge sheetmetal saddle between the pipe hanger/support and the exterior of the insulation. Saddle length shall be the same as insulation inserts.

C. Application at Fittings:

1. Insulation of flanges and flanged fittings shall overlap adjacent pipe covering at least 1 inch. Valves shall be insulated up to the gland only.
2. Pipeline strainers shall be insulated in such a manner as to permit removal of strainer basket without disturbing insulation of the strainer body.
3. Insulation adjacent to uninsulated flanges shall be tapered back and neatly finished so as to allow access to and removal of bolts without injury to covering.

D. Insulation of valves and specialties (including PRVs and RPZs):

1. Apply cut segments of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation with disturbing insulation. For check valves, fabricate removable sections of insulation arranged to allow access to strainer basket.
2. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive. Cement to avoid openings insulation that will allow passage of air to pipe surface.
3. At contractor's option, apply preformed covers manufactured of same material as pipe insulation. Attach per manufacturers installation instructions.

3.02 Type A Insulation Installation:

- A. Tightly butt together sections of insulation on pipe runs sealing longitudinal seams of jacket with a self-sealing adhesive. Seal end joints with 4-inch wide straps of matching vapor barrier tape. Seal off ends of insulation with vapor seal mastic at valves, fittings and flanges. No further finish required. Mastic shall extend onto the bare pipe and over the insulation O.D.
- B. PVC fitting jackets shall be used when they are available for the particular application. When molded or routed coverings are not available, the coverings shall be fabricated in the field similar to equipment insulation. Molded or routed fitting covers are highly recommended. Order PVC pre-curved.
- C. Cold Piping:
 1. Cover valves, fittings and flanges with insulation having the same thickness as adjacent pipe covering, securing in place reforming tape up to 12" O.D. and 1/2" wide SST bands on larger O.D. Apply a PVC jacket and seal joints with PVC cement (solvent welding).
- D. Hot Piping:

1. Covers shall overlap the pipe insulation by the thickness of the insulation or 2" min. Cover valves, fittings and flanges with insulation similar to the adjacent pipe covering, securing in place with reforming tape up to 12" O.D. and ½" wide SST bands on larger O.D. Apply a PVC jacket and tape end joints to adjacent pipe insulation.
2. Do not use PVC fitting jackets where the surface of the insulation is above 150 degrees F.

E. Exterior Piping:

1. Exterior above grade water piping shall be finished with a weatherproof jacket and an aluminum jacket. Lap and seal joints as per manufacturer's instructions. Place laps to shed water.

3.03 Type B Insulation Installation:

- A. Type B insulation shall be slipped on the pipe prior to connection, and the butt joints shall be sealed.
- B. All joints shall be completely butt sealed with the manufacturer's recommended adhesive.
- C. Do not apply Type B insulation in multiple layers.
- D. Type B insulation shall not be used in plenums or firewall penetrations.
- E. This Contractor shall paint Type B insulation exterior to the building with two coats of a vinyl acrylic paint recommended by the insulation manufacturer for protection against ultraviolet degradation and shall be flexible with no cracking. It is recommended in high humid areas to coat the insulation with vapor barrier mastic to .037 min. DFT.

3.04 Type C Insulation Installation:

- A. Exterior:
 1. Butter joints of insulation with non-setting adhesive. Secure with factory applied self-seal laps. Installation shall be as per manufacturer's guidelines.
 2. Finish shall be factory applied all service Jackets. All fittings shall be finished with vapor seal mastic reinforced with white glass mesh. Minimum .037 thick DFT of mastic.
 3. Piping exposed in machine rooms shall be finished with vapor seal mastic and open weave membrane 10 x 10.
 4. Piping exposed to weather shall be finished with all service jacket and additional finish of 0.16 thick aluminum jacket. Aluminum jacket shall be secured with stainless bands located on maximum centers of 12 inches and at the overlap. No screws or pop rivets shall be used.
 5. Fittings and valves shall be finished with vapor seal mastic, reinforced with min. .037" DFT of mastic, glass mesh and aluminum preformed fitting covers.

3.05 Type D and E Insulation Installation:

- A. Equipment Insulation Application:
 1. Apply insulation to fit as closely as possible to equipment.

2. Stagger joints where possible.
3. Bevel insulation around nameplates, ASME stamp and access plates.
4. Insulation on equipment that must be opened periodically shall be constructed so insulation can be removed and replaced without damage.
5. Do not install Type E insulation on aluminum surfaces or with aluminum jacket.

B. Hot Equipment:

1. Install 3/4-inch expanded metal over equipment with standing ribs or seams prior to applying insulation to eliminate ribs or seams penetrating through the insulation.
2. Secure the insulation with steel bands spaced on 12-inch centers.
3. Where required, use welded studs, clips or angles as anchors for wire or bands on flat surfaces.
4. Seal joints with insulating cement.
5. Over the insulation stretch 1-inch hexagonal mesh wire and lace the edges together.
6. Apply a 1/4-inch thick coat of finishing cement and trowel smooth.
7. Smooth insulation with lagging adhesive, cover with glass cloth and a final coat of lagging adhesive.
8. On small equipment where it is not practical, omit the wire mesh and finishing cement on Type D insulation.

C. Cold Equipment:

1. Cover irregular surfaces with a smoothing coat of insulating cement.
2. Secure insulation with wire or with stainless bands spaced on 12-inch centers.
3. Seal joints with vapor seal mastic.
4. Embed a layer of glass into a 1/16-inch coating of vapor seal mastic. Then coat the outside of the glass cloth with a 1/16-inch coating of vapor seal mastic.

D. Roof Drain Bodies:

1. Insulate similar to cold equipment.
2. Insulated boxes around roof drain bodies are not acceptable.

3.06 Type F Insulation Installation:

A. Ductwork Insulation Application:

1. Apply insulation tightly and smoothly to duct.
2. Secure insulation on the bottom of ducts and plenums and on the sides of plenums and other places where the insulation will sag and max 3" from any corner.

3. Impale insulation over pins or anchors located not more than 18 inches apart and hold in place with washers and clips.
4. Cut off protruding pin after clips are secured and seal with 2-mil. aluminum foil backed pressure sensitive tape.
5. Apply insulation with joints tightly butted.
6. Seal all ductwork joints, punctures and fittings with a mastic type sealant containing a vapor barrier.
7. Cover all breaks, joints, punctures and voids with a vapor seal mastic and cover with a vapor barrier material identical to vapor barrier on the insulation, where gaps exceed 2".
8. Bevel insulation around nameplates, access plates and doors.
9. Insulation shall be continuous through walls and floors except at fire dampers.

3.07 Type G Insulation Installation:

A. Internal Lining Insulation Application:

1. Apply where specified herein.
2. Apply liner in accordance with SMACNA Duct Liner Application Standard, later edition.

3.08 Metal Jacket Installation:

- A. Cover all piping insulation exposed to the exterior with metal jacket as specified herein.

3.09 Hangers:

- A. Continue insulation through pipe hangers. Provide either rigid insulation inserts or sheet metal inserts at all outside pipe hangers. Provide rigid insulation inserts for piping operating below 60 °F. and sheet metal inserts for piping above 60 °F.
- B. Provide rigid insulation (on non-insulated piping) or sheet metal inserts (on insulated piping) between the pipe and pipe hanger - shall be of a thickness equal to the adjoining insulation and shall be provided with vapor barrier where required. Insulation insert shall not be less than the following lengths:

1/2" to 2-1/2" pipe size	10 Inches Long
3" to 6" pipe size	12 Inches Long
8" to 10" pipe size	16 Inches Long
12" and over	22 Inches Long

- C. Inserts for cold piping shall have a vapor barrier facing of the same material as the adjacent pipe insulation. Seal inserts into insulation with vapor seal mastic.
- D. Sheet metal inserts shall be of steel sheet. Gauge shall conform to manufacturer's recommendation for pipe size. Sheet metal inserts shall have insulation filler of the same material as the adjacent pipe insulation.

3.10 Pipe Sleeves:

- A. Pipe insulation and vapor barrier shall be continuous through sleeves in walls and floors.
- B. Type B insulation shall not be used in sleeves through firewalls or fire rated (2-hour) floor systems. Use Type A or Type C through the sleeve instead and vapor seal the joint between the two insulations.
- C. Provide 26 gauge galvanized steel or 0.020 inch aluminum jacket over insulation on pipe passing through sleeves where sealant is required.
- D. Where penetrating interior walls, extend the metal jacket 2 inches out either side of the wall and secure each end with a metal band compressing the insulation slightly.
- E. Where penetrating floors, extend the metal jacket 2 inches below the floor and 5 inches above the floor. Secure with metal bands.

END OF SECTION 15250

Section 15400 – Plumbing Piping Systems

Part 1 General

1.01 Related Documents:

- A. A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Provide complete operating plumbing piping systems including pipe, tube, fittings, accessories and appurtenances as indicated and in compliance with these Specifications.

- B. Applications: Applications of piping systems include, but are not limited to, the systems; working pressure and operating temperatures as listed below:

1. Domestic Cold Water

- a. High 350 psig - 55 to 80°F
- b. Medium 300 psig - 55 to 80°F
- c. Low 150 psig - 55 to 80°F

2. Domestic Hot Water

- a. High 350 psig - 90 to 120°F
- b. Medium 300 psig - 90 to 120°F
- c. Low 150 psig - 90 to 120°F

3. Makeup Water

- a. High 350 psig - 55 to 80°F
- b. Medium 300 psig - 55 to 80°F
- c. Low 150 psig - 55 to 80°F

4. Condensate Drainage 40 to 60°F

5. Sanitary Drainage

6. Storm Drainage

1.03 Quality Assurance:

- A. Welding: Qualify welding procedures, welders, and operators in accordance with ANSI B31.1, Paragraph 127.5, for shop and job site welding of piping work. Make welded joints on the piping system with continuous welds, without backing rings and with pipe ends beveled before welding. Gas cuts shall be true and free from burned metal. Before welding, surfaces

shall be thoroughly cleaned. The piping shall be carefully aligned and no weld metal shall project inside the pipe.

Part 2 Products

2.01 Piping Materials:

- A. General: Provide pipe and tube of type, joint, grade, size, and weight (wall thickness, schedule or class) indicated for each service. Comply with applicable governing regulations and industry standards.
1. Steel Pipe: ASTM A53, ASTM A106, or ASTM A120, black or hot-dipped galvanized as specified.
 2. Copper Tube: ASTM B88, Types "K", Type "L", or Type "M" copper water tube as defined by the Copper and Brass Research Association.
 3. Ductile Iron Pipe: ANSI A21.51, Class 150 with bell and spigot ends for push-on joints.
 4. Cast Iron Soil Pipe: ASTM A74, standard weight, hub and spigot-type.
 5. Hubless Cast Iron Pipe: CISPI 301, standard weight with spigot bead ends for coupling assembly.
 6. Polyvinyl Chloride (PVC) Pipe: Sewer main SDR 41, ASTM D3034 with bell ends and pre-inserted gasket joints.
 7. Pre-insulated Steel Pipe: ASTM A53, ASTM A106, ASTM A120, and ANSI B31.1.
 8. Polyvinyl Chloride (PVC) Water Pipe: Class 150, thickwall, Schedule 80, AWWA C90 mechanical joint.
 9. Copper Drainage Pipe: DWV copper piping.
 10. Polyvinyl Chloride (PVC) Drainage Pipe: Schedule 40 PVC.

2.02 Pipe/Tube Fittings:

- A. General: Provide factory-fabricated fittings of type, materials, grade, class, and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve, and equipment connections. Where not otherwise indicated, comply with governing regulations, industry standards, and where applicable, with pipe manufacturer's instructions for selections.
1. Cast Iron Flanged Fittings: ANSI B16.1, Class 125 or Class 250, black or galvanized as specified, including bolting and gasketing.
 2. Cast Iron Threaded Fittings: ANSI B16.4 or ASTM A126, Class 125 or Class 250, black or galvanized as specified.
 3. Malleable Iron Threaded Fittings: ANSI B16.3, Class 150 or Class 300, black or galvanized as specified.

4. Malleable Iron Threaded Unions: ANSI B16.39, select for proper piping fabrication and service requirements including style, end connections, and metal-to-metal seats (iron, bronze, or brass), plain or galvanized as specified.
 5. Threaded Pipe Plugs: ANSI B16.14.
 6. Steel Flanges/Fittings: ANSI B16.5, including bolting, gasketing, and butt weld end connections.
 7. Forged Steel Socket-welding and Threaded Fittings: ANSI B16.11, rated to match schedule of connected pipe.
 8. Wrought Steel Butt-welding Fittings: ANSI B16.9, except ANSI B16.28 for short radius elbows and returns; rated to match connected pipe.
 9. Cast Iron Drainage Fittings: ANSI B16.22 galvanized with pitched threaded ends.
 10. Pipe Nipples: Fabricated from same pipe as used for connected pipe, except do not use less than Schedule 80 pipe where length remaining unthreaded is less than 1/2". Do not thread nipples full length (no all-thread nipples).
 11. Wrought Copper/Bronze Solder-Joint Fittings: ANSI B16.22 suitable for working pressure up to 250 psig.
 12. Hubless Cast Iron Pipe Fittings: CISPI 301-78 and comply with governing regulations.
 13. Cast Iron Soil Pipe Fittings: ASTM A74.
 14. Compression Gaskets: CISPI HSN-75.
 15. Lead/Oakum Joint Materials: Comply with governing regulations for service use indicated.
 16. Grooved End Fittings: ASTM A47 or ASTM A536 joined with Victaulic Style 77 couplings and Grade "E" gaskets.
 17. Flanged Fittings: Comply with ANSI B16.15 for bolt-hole dimensioning, materials, and flange-thickness.
 18. Flange Bolts: Bolts shall be carbon steel ASTM A307 Grade A hexagon head bolts and hexagonal nuts. Where one or both flanges are cast iron, furnish Grade B bolts. Cap screws utilized with flanged butterfly valves shall be ASTM A307 Grade B with hexagon heads.
 19. Flange Bolt Thread Lubricant: Lubricant shall be an anti-seize compound designed for temperatures up to 1000°F and shall be Crane Anti-Seize Thread Compound or approved equal.
 20. Polyvinyl Chloride (PVC) Fittings: ASTM D2665, Carlon, Vylon "Z" high strength sewer fittings.
 21. Copper Drainage Fitting: DWV copper drainage fittings.
- B. Miscellaneous Piping Materials/Products:
1. Welding Materials: Comply with ASME Boiler and Pressure Vessels Code, Section II, Part C, for welding materials.

2. Brazing Materials: American Welding Society, AWS A5.B, Classification BCup-5.
3. Gaskets for Flanged Joints: 1/8" thick gaskets. Ring-type shall be used between raised face flanges and full face-type between flat face flanges with punched bolt holes and pipe opening. Gaskets shall be Garlock Style 3400 compressed non-asbestos or equal.
4. Insulating (Dielectric) Unions: Provide dielectric unions at all pipe connections between ferrous and nonferrous piping. Unions shall be "Delvin" as made by Pipeline Seal and Insulator Company or "EPCO" as made by Epco Sales, Inc. and shall have nylon insulation or equal.
5. Gaskets for Cast Iron Soil Pipe: ASTM C 564, neoprene, compression-type.
6. Push-on-Joints: ANSI A21.11, rubber compression-type, "Tyton Joint" as manufactured by US Pipe or equal.
7. Hubless Cast Iron Joints: CISPI 310, stainless steel corrugated shield and clamp assembly over one piece neoprene sealing sleeve. Coupling sizes through 4" shall have 4 bands and sizes over 4" shall have 6 bands.

2.03 Strainers:

A. General: Water strainers shall be as follows:

1. 150 psig Working Pressure: 150 psig working pressure, 2" and smaller, shall be Muessco No. 11, 400 pounds WOG, iron body with perforated 20 mesh monel screen with cleanout and screwed ends. 150 psig working pressure, 2-1/2 through 24", shall be Muessco No. 751, 150 pounds WOG, perforated monel screen with 1/16" perforations for sizes through 4", and 5/32" perforations for 5" and above, with blowdown connection with full sized gate valve, and Class 125 ANSI B16.1 flanged ends.
2. 300 psig Working Pressure: 300 psig working pressure, 2" and smaller, shall be Muessco No. 11, 400 pounds WOG, iron body with perforated 20 mesh monel screen with cleanout and screwed ends. 300 psig working pressure, 2-1/2 to 24", shall be Muessco No. 752, 300 pounds WOG, perforated metal monel screen with 1/16" perforations in sizes through 4", and 5/32" perforations for 5" and above, with blowdown connection with full sized gate valve, and Class 250 ANSI B16.5 flanges.

B. Manufacturers: Strainers by Mueller, Crane, Muessco, Zurn, or Keckley or equal.

2.04 Escutcheon Plates:

- A. General: Provide escutcheon plates on exposed piping where piping penetrates the walls, floors, or ceilings where penetration is exposed to view including on exterior of building
- B. Provide pipe escutcheons with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated.
- C. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any.
- D. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole is flush with adjoining surface.

2.05 Flexible Connections in Piping:

- A. General: Provide flexible connections in piping where shown on the Drawings or specified under Division 15.
- B. Types: For piping 2" and smaller, flexible pipe connections at pumps and other equipment, where shown, shall be Metal-Flex, Mason Industries or Flexonics double-braided, stainless steel flexible connections with screwed connections. For larger pipe sizes, flexible connections at pumps and other equipment shall be Amber Booth Style 2400, or equal, Flexonics triple bellows reinforced neoprene flexible connections with control units. Victaulic couplings may be used instead of flexible connections where approved by VPTC Management Partners, LLC.

2.06 Sleeves:

- A. General: Provide sleeves for piping passing through walls, floors, and roofs. Sleeves shall be of sufficient size to permit pipe or pipe and insulation, to pass through and leave an annular space for caulking. Sleeves through concrete construction, interior partitions, and ceilings shall be 18 gauge galvanized sheet steel. Masonry construction and exterior penetrations above and below grade shall be Schedule 40 galvanized steel pipe. Extend floor sleeves 2" above floor.
- B. Outside Walls Below Grade: Where pipes pass through outside walls that are below grade, provide schedule 40 galvanized steel pipe with water stop. When pipe is in place, seal with "Link-Seal" Unit with EPDM links as manufactured by Thunderline Corporation, Wayne, Michigan, or approved equivalent.
- C. Fire-rated Floor and Wall Penetration Sleeve packing and caulking shall consist of:
 - 1. Provide the appropriate UL listed and approved materials for floor and wall penetrations.

3.01 Piping Installation:

- A. General:
 - 1. Industry Practices: Install pipe, tube, and fittings in accordance with recognized industry practices which will achieve permanently leakproof piping systems, capable of performing each indicated service without failure or degradation of service. Install each run with a minimum of joints and couplings, but with adequate and accessible unions or flanged connections to permit disassembly for maintenance/ replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align accurately at connections. Coordinate piping locations with other trades to avoid conflict. Give ductwork preference unless directed otherwise by VPTC Management Partners, LLC.
 - 2. Systems: Install piping parallel or perpendicular to lines of building, true to line and grade, and with sufficient hangers to prevent sags between hangers. Provide fittings at changes in direction. Piping in finished areas shall be concealed, except in mechanical rooms. Where pipes of different sizes join, provide reducing elbows, tees, or couplings. Bushings will not be acceptable.
 - 3. Expansion and Contraction: Install loops, offsets, sizing joints, and expansion joints, as necessary, to avoid strain resulting from expansion and contraction of piping systems on fixtures and equipment. Provide mechanical grooved connections required by the application to reduce vibration at equipment connections. Provide expansion joints in piping systems by mechanical grooved connections where required. Provide for expansion every 30 feet of horizontal and vertical PVC piping.

- B. Steel Pipe: Ream steel pipe after cutting and before threading. Thread with clean-cut taper threads of length to engage all threads in fittings and leave no full-cut threads exposed after make-up.
- C. Copper Pipe: Cut copper pipe square and ream to remove burrs. Clean fitting socket and pipe ends with sand cloth or wire brush.
- D. PVC Pipe: Cut PVC pipe square and remove all burrs. Clean fitting and pipe butt prior to installation. Install all PVC piping in accordance with the manufacturer's recommendations.
- E. Final Connections to Equipment Furnished by Owner or Under Other Divisions of These Specifications: Where equipment is to be furnished under other Divisions of these Specifications or by the Owner, such equipment will be delivered to the site, uncrated, assembled, and set in-place under those other Divisions of these Specifications or under the separate contracts. Any required automatic control valves shall also be provided under those other Divisions of these Specifications or other separate contracts. Make all final connections of hot water, condenser water, gas, domestic water, waste, and vent as required. Provide valves, unions, strainers, check valves, and traps as required for proper operation of systems and equipment. Equipment not shown on the Architectural Drawings or noted by VPTC Management Partners, LLC shall not be included in the scope of this requirement.

3.02 Plumbing Services:

- A. Scope:
 - 1. This Contractor shall provide the building sanitary sewer to 5 feet outside the building and shall extend the domestic water service from the main shutoff valve stubbed above floor in the building.
 - 2. Provide storm drainage system as required to 5 feet outside the building.
 - 3. Verify locations and conditions.
- B. General: Install the various piping systems as described hereinafter, and as required by the local plumbing inspection department.
 - 1. Install soil, waste, and vent piping with horizontal lines pitched in accordance with local codes, but in no case less than $\frac{1}{8}$ " per foot for pipe 4" and larger. Install soil, waste, and vent piping with hubs of each length of piping in the upstream position.
 - 2. Make-up lead and oakum joints with molten lead run into hubs in one continuous pour, to a minimum depth of one inch.
 - 3. Make-up "Ty-Seal" or "Dual-Tite" gasketed joints using lubrication and joining tools as instructed by the manufacturers. Base of stacks, horizontal runs under pressure, and gasketed pipe 5" and larger shall be made up using "Lubrifest" joining material.
 - 4. Torque "No-Hub" joints in accordance with manufacturer's instructions. Do not install "No-Hub" joints below ground. Install cast-iron hubless joints in accordance with the recommendations in the CISPI Cast Iron Soil Pipe and Fitting Handbook, Chapter IV.
 - a. Horizontal pipe and fittings 5 inches and larger must be suitably braced to prevent horizontal movement, at every branch opening or change of direction by use of braces, blocks, rodding or other approved method, to prevent movement or joint separation. All elbows and tees shall be braced against thrust loads which might

result in joint separation due to static pressure or dynamic forces caused by sudden, heavy impulse loading (water hammer) conditions

5. Provide chrome-plated piping at each fixture installed in a finished space. Install with proper strap wrenches to avoid marking or defacing.
 6. Provide proper restraints on riser and stack offsets.
- C. Plumbing Connections to Fixtures and Equipment:
1. General: Provide necessary pipe and fittings. Make final connections to provide cold water make-up and natural gas supply to mechanical equipment. Locate cold water make-up and gas supply where shown and connect with suitable stop valves.
 2. Cold Water Make-up: Provide cold water make-up to closed loop condenser water circulating systems, cooling tower system, and hot water heating systems.
- D. The domestic water service shall be Class 150 AWWA cement lined C.I. with Class 250 fittings, mechanical joints or push-on rubber ring gaskets, ASTM A377-66 or PVC AWWA C900 with solvent welded fittings. Provide tie rods and thrust blocks as required.

3.03 [Domestic Hot] and [Cold Water] Piping Systems:

- A. Interior Hot and Cold Water Piping:
1. Aboveground domestic water system piping 3" in size and smaller shall be Type L hard drawn copper tubing with wrought copper fittings and soldered joints.
 2. Aboveground domestic water piping 4" and larger shall be Type L hard drawn copper tubing with rolled grooved joints and fittings.
 3. Provide isolation fitting whenever dissimilar materials are used.
- B. Piping Runouts to Fixtures: Provide piping runouts to fixtures sized to comply with governing regulations. Each fixture shall be provided with a shut-off valve for each supply line. Provide all shutoff valves necessary to isolate mains to each restroom, janitor closet, kitchen/kitchenette, coffee station, etc. Exposed lines shall be chromium-plated. All lines branched off of the riser shall be valved at the riser. All core and future risers shall be valved at the bottom for individual isolation without having to shut off the main.
- C. Water Hammer Arrestors: Provide the necessary water hammer arrestors specifically sized for the application to prevent water hammer. All water hammer arrestors (WHA) shall be PDI Certified, Size A, B, C, D, E or F, as indicated for the fixture units served; Josam, Jay R. Smith or Zurn

3.04 Storm and Sanitary Drainage System:

- A. Soil, Waste, and Vent Piping Underground: Service weight hub and spigot cast iron soil pipe and fittings with lead and oakum joints or neoprene gasket joints made up with "Lubrifest" joining material or PVC piping with solvent welded joints. Provide and install code-approved manholes as required.
1. All PVC piping above ceiling in return air plenums should be fire wrapped. In base bid include any insulation that needs to be added to pass proper municipality inspections

2. All existing sanitary drains that are used should be cabled out at the end of a project to ensure the tenant is getting a new fresh clean line
- B. Storm Drainage Piping Underground: Same as soil, waste, and vent piping underground.
- C. Soil, Waste, and Vent Piping Above Ground: Hubless cast iron pipe and fittings with coupling assembly.
 1. Option: At the Contractor's option, for branch piping only, galvanized steel, Schedule 40, ASTM A53 pipe with galvanized malleable iron fittings for vent piping and galvanized cast iron drainage fitting for soil and waste piping may be used instead of the above. NOTE: Use PVC piping with solvent welded joints only where allowed by code.
- D. Storm Piping Above Grade: Service weight hubless cast iron soil pipe and fittings with coupling assembly, or Schedule 40 PVC pipe with PVC drainage fittings. NOTE: Use PVC only where allowed by code.
- E. Pump Discharge Piping: Discharge from pumps to the horizontal gravity main shall be Schedule 40 galvanized steel with galvanized cast iron drainage fittings, or Schedule 40 PVC piping and fittings where code allows. Each pump discharge shall be carried separately to the horizontal gravity main and shall discharge into the top of the horizontal gravity main.
- F. Cleanouts: storm and sanitary
 1. General: Care shall be used when locating cleanouts. Wherever possible, do not place cleanouts in "finished" areas. All locations shall be approved by VPTC Management Partners, LLC and the Architect.
 2. Finished Floor: Zurn ZB-1400, cast iron adjustable assembly with nickel bronze cover and tapered thread bronze plug. Provide clamping collar when installed in floors having waterproof membrane.
 3. Unfinished Areas: Zurn No. Z-1400 Supremo cleanout with cadmium-plated, cast iron plug.
 4. Walls: Zurn Z-1440-3, cast iron with nickel bronze, square, smooth, access cover, vandal-proof screws.
 5. Outside: Zurn Z-1420-25, non-slip, vandal-proof cover with anchoring lugs. Provide with traffic grade top where exposed to vehicle traffic.
 6. Locations:
 - a. At base of every drainage stack
 - b. At every restroom branch, provide a cleanout at its upper terminal..
 - c. In horizontal runs at each change in direction of piping greater than 45 degrees and at minimum intervals of 50' for piping 4" and smaller and 100' for larger piping.
 - d. As required by local code.

3.05 Cleaning, Flushing, Testing, and Inspecting:

- A. Cleaning: Clean exterior surfaces of installed piping systems and prepare surface for application of any required coatings.

- B. Flushing: Flush piping systems with clean water prior to performing any required tests.
- C. Piping Tests:
1. General: Blank off equipment during tests. Perform tests before piping is enclosed in walls, floors, partitions or in any other way concealed from view. Tests may be performed in sections. Tests shall be witnessed by VPTC Management Partners, LLC and local inspectors and the test results presented to VPTC Management Partners, LLC for acceptance and approval prior to concealing piping from view. Provide all necessary equipment for testing, including pumps and gauges. Note: All test results are to be submitted to VPTC Management Partners, LLC as specified in Section 15995.
 2. Domestic Water Systems: Test hot and cold water systems hydrostatically to a pressure of 150 psig or 1-1/2 times working pressure, whichever is greater, for a period of 4 hours. Repair all leaks, replacing materials as necessary, and repeat tests until systems are proven tight.
 3. Soil, Waste, and Vent Piping System: Test soil, waste, and vent piping by plugging all openings and filling system to height required by City Plumbing Inspector, but not less than 10'. Inspect all joints for leaks, repair all leaks found, and retest until piping is demonstrated to be free from leaks. In addition to water test, apply peppermint or smoke tests, if required by local code. All underground main piping shall be inspected with a camera and the taped test results submitted to VPTC Management Partners, LLC.
 4. Storm Drainage Piping System: Test storm drainage piping same as specified for Soil, Waste, and Vent Piping System.
 5. Disinfecting of Water Systems: Disinfect as required by code. Where code does not dictate tests to be conducted, at a minimum disinfect the hot and cold water systems as follows: Fill systems with water solution containing 50 ppm available chlorine; allow to stand for 4 hours, opening and closing all valves several times during this period; thoroughly flush; refill and place system in service; ensure a residual chlorine content of 2.5 ppm.
 6. Cleaning and Adjusting: Thoroughly clean and disinfect all plumbing fixtures, including all exposed trim. Adjust all flush valves for proper flushing, but without excess use of water.
- D. Inspecting: Visually inspect each run of each system for completion of joints, adequate hangers, supports, and inclusion of accessories and appurtenances.
- E. Chemical Treating: Refer to Section 15545, "Water Treatment Systems", for flushing and cleaning systems.
- F. Identification: Refer to Section 15190, "Mechanical Identification" for nameplates and labeling requirements.

3.06 Misc

The use of hub drains are not approved by VPTC Management Partners, LLC. Tenant specific equipment like ice machines etc will require its own pump that discharges into the drainage system separately. Any existing hub drain will be required to be removed and capped below floor.

END OF SECTION 15400

Section 15440 – Plumbing Fixtures and Trim

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Provide plumbing fixtures as specified.
- B. Work of Other Sections: Section 15510, "Hydronic Piping Systems".

1.03 Quality Assurance:

- A. Electrical Standards: Provide electrical products which have been tested, listed, and labeled by Underwriters' Laboratories, Inc. (UL) and which comply with National Electrical Manufacturers' Association (NEMA) standards.
- B. Acceptable Manufacturers: The model numbers listed in the Specifications establish a level of quality and material. The following manufacturers are acceptable subject to compliance with the requirements of the basis-of-spec products listed in these Specifications.
 - 1. Electric Water Heaters
 - a. A. O. Smith, Inc.
 - b. Bradford White
 - c. Lochinvar
 - d. Rheem
 - e. Ruud
 - f. State Industries
 - 2. Fixtures:
 - a. American Standard
 - b. Crane Company
 - c. Eljer Plumbing Ware
 - d. Kohler Company
 - e. Toto USA
 - f. Zurn Industries, Inc.
 - 3. Faucets:

- a. American Standard
 - b. Bradley Corp.
 - c. Chicago Faucet Company
 - d. Delta Faucet
 - e. Eljer Plumbing Ware
 - f. Elkay Mfg. Company
 - g. Just Mfg. Company
 - h. Kohler Company
 - i. Sloan Valve Company
 - j. Speakman Company
 - k. Symmons
 - l. T & S Brass and Bronze Works, Inc.
 - m. Zurn Industries, Inc.
4. Flush Valves:
- a. Sloan Valve Company
 - b. Zurn Industries, Inc.
5. Seats:
- a. Beneke Corporation
 - b. Bemis
 - c. Church Products, Forbes-Wright Ind., Inc.
 - d. Olsonite Corporation
6. Carriers:
- a. Josam
 - b. J. R. Smith Mfg. Co.
 - c. Wade Div./Tyler Pipe
 - d. Zurn Industries, Inc.
7. Drinking Fountains:
- a. Ebco/Oasis
 - b. Elkay Mfg. Company
 - c. Halsey Taylor - Div. Household Int. Co.

8. Stainless Steel Sinks:
 - a. American Standard
 - b. Dayton
 - c. Elkay Mfg. Company
 - d. Just Mfg. Company
 - e. Kohler Company

Part 2 Products

2.01 **Electric Water Heaters:**

- A. Heaters shall be guaranteed for 3 years against tank failure. Tanks shall be glass-lined with a minimum of 3" fiberglass insulation, factory-installed magnesium anodes, immersion type heating elements, high limit control and other necessary operating and safety controls.
- B. Provide a combination pressure and temperature relief valve complying with ANSI 21.22 with full size discharge pipe.
- C. Water heater size and capacity shall be as required to meet the water heating needs for each installation.
- D. Point of use water heaters shall not be used unless otherwise directed by VPTC Management Partners, LLC.

2.02 **Water Closets:**

- A. [Water Closet, WC-1:]
 1. Fixture: American Standard No. 2257.103, "Afwall" white vitreous china, siphon jet, 1.6 gallons per flush, elongated bowl, wall hung, with 1-1/2" top inlet.
 2. Seat: Olsonite No. 95 white, open front.
 3. [Flush Valve: Sloan "Royal" 111 (for non LEED buildings)].
 4. Carrier: Suitable for intended service.
- B. [Water Closet, WC-2 (ADA Compliant):]
 1. Fixture: American Standard No. 2257.103, "Afwall" white vitreous china, siphon jet, 1.6 gallons per flush, elongated bowl, wall hung, with 1-1/2" top inlet.
 2. Seat: Olsonite No. 95 white, open front.
 3. Flush Valve: Sloan "Royal" 111 (for non LEED buildings)].
 4. Carrier: Suitable for mounting at ADA required height.

2.03 Lavatories:

A. [Lavatory, L-1: (ADA Compliant)]

1. Fixture: American Standard #0476.028 Aqualyn 20" x 17" vitreous china, self-rimming, oval lavatory complete with front overflow, 4" center faucet holes and 1 1/4" drain.
2. Trim: American Standard Selectronic Innsbrook 6056.205 faucet, electronic proximity operation, all brass body with single inlet, built-in check valve and in-line strainer low energy use electronically operated solenoid valve and microprocessor controlled proximity sensors, 0.5 G.P.M. vandal resistant aerator, supply fitting. AC powered plug-in integral low voltage transformer 115 VAC supply, chrome-plated tailpieces, strainers, P-trap, supply stops and all other trim
3. Supplies: Angle stop valves with escutcheons, 1/2" inlet, chrome-plated. Limit stops shall indicate maximum hot and cold water. Install for barrier free use, offset wall supply stops, drains, tailpieces and insulated drain and water supplies as required.

2.04 Sinks:

A. [Sink, S-1:]

1. Fixture: Elkay DLR-1722-10, self rim type 304 stainless steel, 10" deep with 1-3/4" radius covered corners. The underside of the sink shall be fully undercoated.
2. Faucet: Sink shall be fitted with Elkay LK-2442-BH, Hi-arc, dual blade handle, deck-mounted faucet.
3. Drain and P-trap: Provide Elkay chrome plated brass drain outlet with 1-1/2" O.D. tailpiece. Provide 1-1/2" X 1-1/2" P-trap with cleanout, slip joint inlet and 17 gauge tubing outlet to wall and wall escutcheon.
4. Supply and Stop: Provide supply and angle stop valves with escutcheons, 3/8" inlet, and chrome plated.

B. [Sink, S-2 (two-compartment):]

1. Fixture: Elkay DLR-3322-10, two-compartment self rim type 304 stainless steel, 10" deep with 1-3/4" radius covered corners. The underside of the sink shall be fully undercoated.
2. Faucet: Sink shall be fitted with Elkay LK-2443, Hi-arc, dual blade handle, deck-mounted faucet with sprayer.
3. Drain and P-trap: Provide Elkay chrome plated brass drain outlet with 1-1/2" O.D. tailpiece. Provide 1-1/2" X 1-1/2" P-trap with cleanout, slip joint inlet and 17 gauge tubing outlet to wall and wall escutcheon.
4. Supply and Stop: Provide supply and angle stop valves with escutcheons, 3/8" inlet, and chrome plated.

C. [Sink, S-3 (ADA Compliant):]

1. Fixture: Single compartment, 18 gauge stainless steel with sound-deadening, 13" x 16" outside dimensions, 10" x 10" inside dimensions, 6 1/2" deep; Elkay Model No. LRADQ-1316. Faucet punching shall be 3 hole; drain opening off-center rear.

2. Faucet: Set shall match the punching and shall be deck-mounted, lever-style chrome-plated, all brass, gooseneck faucet with aerator and wrist blade handles; American Standard Heritage 6832 series and a stainless steel drain, cup strainer and rubber stopper. Provide complete trim such as service stops, tailpieces and P-trap.

2.05 Urinals:

A. Urinal, U-1:

1. Fixture: American Standard, "Allbrook" Mod. 6541.132, wall hung, white vitreous china, 1.0 gallon per flush, 3/4-inch top inlet siphon jet.
2. Flush Valve: Sloan "Royal" No. 8186-1.0 battery-operated valve or approved equal.
3. Carrier: Suitable for intended service.

B. Urinal, U-2 (ADA Compliant):

1. Same as specified for U-2, accept mounted at ADA required height.

2.06 Electric Drinking Fountains:

A. Electric Drinking Fountain, EDF-1:

1. Fixture: Elkay No. EBFATL-8 stainless steel, combination (double unit, ADA Compliant) wall-mounted, barrier-free type with push bar water controls and hermetically sealed compressor using CFC-free refrigerant.
2. Trim: Angle stop valve with 1/2" inlet and 1-1/4" x 1-1/2" cast brass P-trap.
3. Support: Elkay wall mounting frame.

2.07 Janitor's Receptor:

- A. Service Sink, SS-1: Williams "Servi-I-Ceptor", Fiat, or Twin City Granitine "Red-E-Basin," 24" x 24" x 6", 3" trap and Chicago 897 Faucet with vacuum breaker mounted 44" above floor. Provide 3' length of 3/4" garden hose threaded to connect to faucet. Provide stainless steel rim guard on exposed sides and stainless steel wall guards for walls adjacent to the receptor. Mount receptor level on floor, providing grout as required.

2.08 Hose Bibs and Wall Hydrants:

- A. Hose Bib, HB-1: Chicago Faucet No. 387, 3/4" female inlet, and No. E27 non-removable vacuum breaker, all polished chrome-plated.
- B. Wall Hydrant, WH-1: Non-freeze wall hydrants (NFWH) shall be non-freeze, bronze box type with vacuum breaker, loose key and wall clamp. Finish shall be rough bronze. Wall hydrants shall be Smith 5509QTPB or approved equal by Josam or Zurn.

2.09 [Emergency Eyewash & Showers:]

- A. Emergency Shower: When required per plan or chemical type(s) being used, a Guardian Equipment G1902P or equal, free-standing shower and eye wash, complete with deluge shower head, one inch full flow stay open ball valve actuated by pull rod and ring, aerated eye

wash with plastic bowl and hand operated one half inch full flow stay open ball valve, , floor flange, and interconnecting fittings. Unit shall be securely anchored to wall and floor.

- B. Emergency Eyewash: All water cooled buildings containing a water treatment area shall be equipped with a Guardian Equipment G1814P or equal aerated eyewash station with plastic bowl and hand operated one half inch full flow ball valve securely mounted to a wall or other suitable structure.

2.10 [Showers:]

- A. Shower: Shower shall be equal to Symmons 4-500-X single control pressure balanced shower valve with lever handle, volume control and integral stop-checks, high temperature limit stop set in field at 110° F. 4-131-2.5 super shower head with integral 2.5 gpm flow restrictor, 301 Nu-Arm head bracket fitting.

Part 3 - Execution

3.01 Installation:

- A. Heights: Set fixtures at heights as shown on the Architect's Drawings.
- B. Caulking: This Contractor shall caulk the joint between the finished wall surface and all plumbing fixtures. Verify colors with the Architect. Caulking material shall comply with the appropriate section of these Specifications.
- C. Emergency Eyewash & Shower: Install an emergency eyewash and when required, a combination emergency shower and eye wash adjacent to the chemical treatment feeder system, and in other locations as required by code or as indicated on the drawings. Station to be provided with tempered water between 65 and 95 degrees Fahrenheit. All installation means and methods to comply with any applicable plumbing specifications.
- D. Each fixture shall be provided with a shut-off valve for each supply line. All exposed lines shall be chromium-plated.
- E. Installation of electric water heaters shall be in accordance with manufacturer's written instructions.
- F. A drain pan is to be installed under all water heaters. The drain for the pan is to be piped to the nearest floor drain, mop basin or other approved point of safe discharge. The water heater needs to be installed at an elevation that will permit gravity draining of the drain pan. Install piping and appurtenances so that discharge will not overflow from drain.
- G. Water heaters shall be installed in a readily accessible location.
- H. For water heaters serving general lavatories, water temperature shall be set to 110°F. For water heaters serving kitchen areas, set water temperature at 140°F or as required by local codes.

END OF SECTION 15440

Section 15510 – Mechanical Piping Systems

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Provide complete operating mechanical piping systems including pipe, tube, fittings, and appurtenances as indicated and in compliance with these Specifications.
- B. Applications: Applications of piping systems include, but are not limited to, the systems as listed below:
1. **[Refrigeration]** 40 to 60°F
 2. **[Chilled Water]** 40 to 60°F
 3. **[Condensate Drainage]** 40 to 60°F
 4. **[Condenser Water]** 65 to 100°F
 5. **[Heating Water]** 100 to 180°F
 6. **[Generator Exhaust]** 900 to 1400°F

1.03 1.03 Quality Assurance:

- A. Welding: Qualify welding procedures, welders, and operators in accordance with ANSI B31.1, Paragraph 127.5, for shop and job site welding of piping work. Make welded joints on the piping system with continuous welds, without backing rings and with pipe ends beveled before welding. Gas cuts shall be true and free from burned metal. Before welding, surfaces shall be thoroughly cleaned. The piping shall be carefully aligned and no weld metal shall project inside the pipe.

Part 2 Products

2.01 Piping Materials:

- A. General: Provide pipe and tube of type, joint, grade, size, and weight (wall thickness, schedule or class) indicated for each service. Comply with applicable governing regulations and industry standards.
1. Steel Pipe: ASTM A53, ASTM A106, or ASTM A120, black or hot-dipped galvanized as specified.
 2. Copper Tube: ASTM B88, Types "K", Type "L", or Type "M" copper water tube as defined by the Copper and Brass Research Association.

3. Pre-insulated Steel Pipe: ASTM A53, ASTM A106, ASTM A120, and ANSI B31.1.
4. Polyvinyl Chloride (PVC) Water Pipe: Class 150, thick wall, Schedule 80, AWWA C90 mechanical joint.
5. Copper Drainage Pipe: DWV copper piping.

2.02 Pipe/Tube Fittings:

- A. General: Provide factory-fabricated fittings of type, materials, grade, class, and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve, and equipment connections. Where not otherwise indicated, comply with governing regulations, industry standards, and where applicable, with pipe manufacturer's instructions for selections.
1. Cast Iron Flanged Fittings: ANSI B16.1, Class 125 or Class 250, black or galvanized as specified, including bolting and gasketing.
 2. Cast Iron Threaded Fittings: ANSI B16.4 or ASTM A126, Class 125 or Class 250, black or galvanized as specified.
 3. Malleable Iron Threaded Fittings: ANSI B16.3, Class 150 or Class 300, black or galvanized as specified.
 4. Malleable Iron Threaded Unions: ANSI B16.39, select for proper piping fabrication and service requirements including style, end connections, and metal-to-metal seats (iron, bronze, or brass), plain or galvanized as specified.
 5. Threaded Pipe Plugs: ANSI B16.14.
 6. Steel Flanges/Fittings: ANSI B16.5, including bolting, gasketing, and butt weld end connections.
 7. Forged Steel Socket-welding and Threaded Fittings: ANSI B16.11, rated to match schedule of connected pipe.
 8. Wrought Steel Butt-welding Fittings: ANSI B16.9, except ANSI B16.28 for short radius elbows and returns; rated to match connected pipe.
 9. Pipe Nipples: Fabricated from same pipe as used for connected pipe, except do not use less than Schedule 80 pipe where length remaining unthreaded is less than 1/2". Do not thread nipples full length (no all-thread nipples).
 10. Wrought Copper/Bronze Solder-Joint Fittings: ANSI B16.22 suitable for working pressure up to 250 psig.
 11. Grooved End Fittings: ASTM A47 or ASTM A536 joined with Victaulic Style 77 couplings and Grade "E" gaskets.
 12. Flanged Fittings: Comply with ANSI B16.15 for bolt-hole dimensioning, materials, and flange-thickness.
 13. Flange Bolts: Bolts shall be carbon steel ASTM A307 Grade A hexagon head bolts and hexagonal nuts. Where one or both flanges are cast iron, furnish Grade B bolts. Cap screws utilized with flanged butterfly valves shall be ASTM A307 Grade B with hexagon heads.

14. Flange Bolt Thread Lubricant: Lubricant shall be an anti-seize compound designed for temperatures up to 1000°F and shall be Crane Anti-Seize Thread Compound or approved equal.
15. Copper Drainage Fitting: DWV copper drainage fittings.

B. Miscellaneous Piping Materials/Products:

1. Welding Materials: Comply with ASME Boiler and Pressure Vessels Code, Section II, Part C, for welding materials.
2. Brazing Materials: American Welding Society, AWS A5.B, Classification BCup-5.
3. Gaskets for Flanged Joints: 1/8" thick gaskets. Ring-type shall be used between raised face flanges and full face-type between flat face flanges with punched bolt holes and pipe opening. Gaskets shall be Garlock Style 3400 compressed non-asbestos or equal.
4. Insulating (Dielectric) Unions: Provide dielectric unions at all pipe connections between ferrous and nonferrous piping. Unions shall be "Delvin" as made by Pipeline Seal and Insulator Company or "EPCO" as made by Epco Sales, Inc. and shall have nylon insulation or equal.
5. Push-on-Joints: ANSI A21.11, rubber compression-type, "Tyton Joint" as manufactured by US Pipe or equal.

2.03 Strainers:

A. General: Water strainers shall be as follows:

1. 150 psig Working Pressure: 150 psig working pressure, 2" and smaller, shall be Muessco No. 11, 400 pounds WOG, iron body with perforated 20 mesh Monel screen with cleanout and screwed ends. 150 psig working pressure, 2-1/2 through 24", shall be Muessco No. 751, 150 pounds WOG, perforated monel screen with 1/16" perforations for sizes through 4", and 5/32" perforations for 5" and above, with blowdown connection with full sized gate valve, and Class 125 ANSI B16.1 flanged ends.
2. 300 psig Working Pressure: 300 psig working pressure, 2" and smaller, shall be Muessco No. 11, 400 pounds WOG, iron body with perforated 20 mesh Monel screen with cleanout and screwed ends. 300 psig working pressure, 2-1/2 to 24", shall be Muessco No. 752, 300 pounds WOG, perforated metal monel screen with 1/16" perforations in sizes through 4", and 5/32" perforations for 5" and above, with blowdown connection with full sized gate valve, and Class 250 ANSI B16.5 flanges.

B. Manufacturers: Strainers by Mueller, Crane, Muessco, Zurn, Keckley or equal.

2.04 Sleeves:

- A. General: Provide sleeves for piping passing through walls, floors, and roofs. Sleeves shall be of sufficient size to permit pipe or pipe and insulation, to pass through and leave an annular space for caulking. Sleeves through concrete construction, interior partitions, and ceilings shall be 18 gauge galvanized sheet steel. Masonry construction and exterior penetrations above and below grade shall be Schedule 40 galvanized steel pipe. Extend floor sleeves 2" above floor.

- B. Outside Walls Below Grade: Where pipes pass through outside walls that are below grade, provide schedule 40 galvanized steel pipe with water stop. When pipe is in place, seal with "Link-Seal" Unit with EPDM links as manufactured by Thunderline Corporation, Flexicraft, Wayne, Michigan, or approved equivalent.
- C. Fire-rated Floor and Wall Penetration Sleeve packing and caulking shall consist of:
 - 1. Provide the appropriate UL listed and approved materials for floor and wall penetrations.

2.05 Escutcheon Plates:

- A. General: Provide escutcheon plates on exposed piping where piping penetrates the walls, floors, or ceilings where penetration is exposed to view including on exterior of building
- B. Provide pipe escutcheons with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated.
- C. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any.
- D. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole is flush with adjoining surface.

2.06 Flexible Connections in Piping:

- A. General: Provide flexible connections in piping to isolate vibrations from mechanical equipment or as specified under other Division 15 sections.
- B. Types of Flexible Connections:
 - 1. Metal Expansion Joints:
 - a. Stainless steel corrugated bellows with woven flexible stainless steel wire reinforcing protective jacket; minimum 150 psig working pressure, maximum 250 deg. F operating temperature, capable of 3/4 inch misalignment.
 - b. Sizes 4" and smaller shall have single-braid outer jacket; sizes larger than 4" shall have double-braid to achieve minimum 150 psig rating. For applications with operating pressures greater than 150 psig, provide triple-braided.
 - c. Provide screwed connections for piping sizes 2" and smaller; flanged end connections on sizes larger than 2".
 - 2. Non-Metallic Expansion Joints:
 - a. Double-spherical neoprene connectors shall be manufactured of multiple plies of nylon tire cord fabric and neoprene both molded and cured in hydraulic rubber presses. No steel wire or rings shall be used as pressure reinforcement.
 - b. Connectors up to and including 1-1/2" diameter may have threaded ends. Connectors 2" and larger shall be manufactured with floating galvanized flanges recessed to lock the connector's raised face neoprene flanges.
 - c. Connectors shall be rated a minimum of 150 psig at 220° F. 12" and larger sizes operating above 100 psig shall employ control cables with end fittings isolated by

means of 1/2" thick bridge bearing neoprene washer bushings designed for a maximum of 1000 psig.

- d. Non-metallic expansion joints may only be used on critical applications where required by an acoustical consultant and as directed by VPTC Management Partners, LLC.

3. Flexible Hose Connections:

- a. Flexible hoses shall have an EPDM Kevlar reinforced tube core with 304 stainless outer braid, brass end fittings and a rating of 400 psig, 250F. Hoses shall be full port, fire retarding and conform to ASTM E84 and E81A. All hoses shall have minimum one swivel end fitting.
- b. Flexible hose connections shall only be used for connection of water source heat pumps; maximum 1" piping size.

C. Provide flexible connections by one of the following manufacturers:

1. Flexicraft Industries
2. Hyspan
3. Mercer Rubber Company
4. Metal Flex
5. The Metraflex Company
6. Senior Flexonics

D. All connectors shall be installed on the equipment side of the shut-off valves.

Part 3 **Execution**

3.01 **Piping Installation:**

A. General:

1. Industry Practices: Install pipe, tube, and fittings in accordance with recognized industry practices which will achieve permanently leak proof piping systems, capable of performing each indicated service without failure or degradation of service. Install each run with a minimum of joints and couplings, but with adequate and accessible unions or flanged connections to permit disassembly for maintenance/ replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align accurately at connections. Coordinate piping locations with other trades to avoid conflict. Give ductwork preference unless directed otherwise by VPTC Management Partners, LLC.
2. Systems: Install piping parallel or perpendicular to lines of building, true to line and grade, and with sufficient hangers to prevent sags between hangers. Provide fittings at changes in direction. Piping in finished areas shall be concealed, except in mechanical rooms. Where pipes of different sizes are joined, provide reducing elbows, tees, or couplings. Bushings will not be acceptable.

3. Expansion and Contraction: Install loops, offsets, sizing joints, and expansion joints, as necessary, to avoid strain resulting from expansion and contraction of piping systems on fixtures and equipment.
 4. Piping in Shafts: Mechanical joints for mechanical piping systems are not to be installed in locations that will not be accessible after construction is complete. (i.e. grooved fittings are not to be used on piping systems in shafts. The piping in this area is to be welded.)
- B. Steel Pipe: Ream steel pipe after cutting and before threading. Thread with clean-cut taper threads of length to engage all threads in fittings and leave no full-cut threads exposed after make-up.
- C. Copper Pipe: Cut copper pipe square and ream to remove burrs. Clean fitting socket and pipe ends with sand cloth or wire brush.
- D. PVC Pipe: Cut PVC pipe square and remove all burrs. Clean fitting and pipe butt prior to installation. Install all PVC water service piping in accordance with the manufacturer's recommendations.
- E. Final Connections to Equipment Furnished by Owner or Under Other Divisions of These Specifications: Where equipment is to be furnished under other Divisions of these Specifications or by the Owner, such equipment will be delivered to the site, uncrated, assembled, and set in-place under those other Divisions of these Specifications or under the separate contracts. Any required automatic control valves shall also be provided under those other Divisions of these Specifications or other separate contracts. Make all final connections of hot water, condenser water, gas, domestic water, waste, and vent as required. Provide valves, unions, strainers, check valves, and traps as required for proper operation of systems and equipment. Equipment not shown on the Architectural Drawings or noted by VPTC Management Partners, LLC shall not be included in the scope of this requirement.
- F. Excavation, Installation, and Backfill for Underground Pipe:
1. Layout: Pipes shall be laid and pipe joints made in presence of VPTC Management Partners, LLC. Field measurements, layouts, batter board alignment, grade establishments, and similar locations shall be performed by a Professional Engineer or Surveyor in the employ of the Contractor. The Contractor's engineer or surveyor shall be on the job during all underground work. A "Bench-Mark" reference for use by the Contractor shall be provided by VPTC Management Partners, LLC.
 2. Pipe Grading: Lay and maintain all pipes at required lines and grades during the course of the Work.
 3. Trench: Excavate the trench to the depth required. Properly brace and de-water the trench and keep it free of water during installation, testing pipe, and backfilling. No water shall be discharged onto the street or freeway without approval by VPTC Management Partners, LLC.
 4. Excavation: The trench shall be at least 18" wider than the maximum diameter of the pipe or largest fitting and the pipe shall be laid in the center of the trench. The trench shall be excavated to a depth sufficient to provide for pipe cushions or supports as specified. Trench width may be increased as required and piling left in place until sufficient compacted backfill is in place. Properly sheet and brace all open trenches to render them secure and remove all such sheeting and bracing before completing the backfill. Comply with all applicable national, state, and local codes and regulations. The quantity of excavation required to install sheeting and the installation and removal of

sheetings and bracings will not be regarded as Extra Work. All costs incurred for this excavation and the installation of sheeting shall be included in the Contract Price.

5. Grading: Upon completion of excavation and prior to the laying of the pipe, the trench bottom shall be brought up to the required elevation with a pipe cushion, except where the cushion has been eliminated by VPTC Management Partners, LLC. Pipe cushions shall be select material deposited in the trench and shall be compacted, leveled off, and shaped to obtain a smooth compacted bed along the laying length of the pipe. Pipe cushion material shall be as follows:
 - a. Open and Closed Loop Condenser Water and Hot Water Heating Piping: Material for pipe cushion shall comply with local codes and conform to the geo-technical report. In absence of local code requirements and/or geo-technical report, the cushion shall be bank sand or select backfill material approved by VPTC Management Partners, LLC.
6. Anchors: Pipes shall have concrete anchors at each change in direction and/or as directed. Any change in direction exceeding 15 degrees shall be anchored. Concrete anchors shall rest against solid (virgin) ground with the required area of bearing on pipe and ground to provide suitable anchoring.
7. Backfill: Backfill trenches only after piping has been inspected, tested, and approved by VPTC Management Partners, LLC. Backfill shall be provided as recommended in the geo-technical report included in these Contract Documents, or, in the absence of a geo-technical report, as required by site conditions. Refer to Division 2 or elsewhere in the Contract Documents for additional trenching and backfill requirements.
8. Existing Surfaces: Restore existing streets, driveways, and sidewalks damaged during the excavation work to acceptable condition, subject to approval by VPTC Management Partners, LLC.
9. Safety: Provide street and sidewalk excavations with approved barricades, warning lights, and cover plates as required by the local authorities.

G. Pipe Sleeves:

1. Size and install sleeves so piping and insulation (if any) will have free movement in the sleeve, including allowance for thermal expansion. Install length of sleeve equal to thickness of construction penetrated, except as noted in Paragraph 2.04/A. Pack and caulk or otherwise seal between pipes and sleeve as specified in Paragraph 2.04.
2. Where pipes or ducts pass through floors, furnish sleeves at a minimum of 1" larger than outside diameter of pipe or duct and insulation, or as required by code.
3. After installing pipe, grout or caulk sleeves through non fire walls to make watertight.
4. Provide sleeves for pipe installation under footings. Provide a slurry fill for pipe passing under floors.
5. Extend sleeves one foot beyond each side of footing.
6. Make installation of pipes passing through exterior walls watertight.
7. Pack and caulk sleeves as required.
8. Where sleeves are set in walls for future connections, close openings in sleeves with foam sealant.

9. Seal between ducts and sleeves where ducts penetrate floor, wall or ceiling with safing insulation. Seal shall maintain wall rating.
10. Where pipes pass through walls below grade into excavated areas such as pits, tunnels or basements, furnish pipe sleeve 1" or one pipe size larger than pipe and close opening with hydrostatic seals.
11. Coordinate with work of masons to properly locate sleeves so that sleeves are true to line, grade, position and plumb or level, ends of sleeves through walls are flush with finished wall surface and, in areas where floors are likely to become wet, ends of sleeves through floors are set 4" above finished floor.

3.02 [Open and Closed Loop Chilled Water, Condenser Water and Heating Water Piping Systems:]

- A. General: On each floor, provide isolating valves on core water supply and return mains to permit half of the floor to be isolated while maintaining service to the other half of the floor.
- B. Aboveground Pipe: Black steel, ASTM A53, Schedule 40, up to 12" and standard weight for 12" and above. As an option for piping below 1 ½", provide Type L hard drawn copper tubing meeting ASTM B88 or ASTM B280. Fittings - Wrought copper meeting ANSI B16.22. Joints - Silver brazed with sil-fos or silver solder.
- C. Underground Piping: Polyvinyl Chloride (PVC) Water Pipe: Class 150, thickwall, Schedule 80, AWWA C90 mechanical joint.
- D. Fittings:
 1. Service Pressure at or Less Than 150 psig:
 - a. Fittings, 2" in diameter and smaller, threaded, Class 150 rated, black, banded, malleable iron.
 - b. Fittings, 2-1/2" in diameter and larger, factory-fabricated, Class 150, weld-type.
 - c. Flanges, Class 150, forged steel weld neck.
 2. Taps and Branches: "Weld-O-Lets", "Thread-O-Lets", or "Branch-Lets" may be employed at locations where taps or branches join line pipe, provided the tap or branch does not exceed 1/2 the size of the line pipe. Factory-fabricated wye and tee fittings may be welded into the main.
 3. Service Pressure Greater Than 150 psig:
 - a. Fittings, 2" in diameter and smaller, threaded, 300 psig, black, banded, malleable iron.
 - b. Fittings, 2-1/2" in diameter and larger, factory-fabricated, weld-type, rated for greater than 300 psig.
 - c. Flanges, 300 psig, weld neck, welding flanges at valves and all flanged connections.
- E. Contractor Options:
 1. Schedule 40 pipe with cut grooves and victaulic fittings may be used for 2-1/2" and above.

F. Cold-springing: Cold-springing of piping will not be permitted.

G. Automatic Air Vents:

1. An automatic air vent shall be installed at the air separator and piped to the floor drain, at a minimum. All other system high points and at other locations as required, shall be manually vented. Vents shall be designed to eliminate air from the system automatically and/or manually without permitting the passage of any water and shall be similar and approved equal to the following:
 - a. 150 psig working pressure service - Sarco Type 13W or approved equal.
 - b. 300 and 400 psig working pressure service - Sarco Type 13WH or approved equal.
2. Automatic air vents shall have a 3/4" ips inlet connection and 3/8" outlet. Provide 3/8" OD hard drawn, Type "L" copper tubing from vent outlet for overflow in case of defective action. Copper tubing shall run to a suitable drain. Provide 3/4" stop valve in vent line for servicing of automatic air vent.

3.03 [Condensate Drainage:]

- A. General: Provide a condensate drain pipe to connect each cooling unit drain pan or funnel and to extend to and discharge into an open type drain in the sanitary plumbing system. Funnel type floor drain requirements are to be coordinated with the Plumbing Contractor. Provide union or solder joint at connection to heat pumps.
- B. Assembly: Use hard drawn Type "M" or DWV copper tubing with matching fittings, or Schedule 40, galvanized steel made up with Class 125, galvanized, threaded fittings. Assemble fittings to form a trap with depth equal to or greater than operating pressure of the unit served. Drains shall be of the size not less than the full size of the drain pan connection. Air handling unit drains shall have deep seal traps to permit unit pan drainage. The deep seal trap shall be installed for each blow-through or draw-through air handling unit to maintain the water seal.

3.04 [Refrigerant Piping:]

- A. General: Refrigerant piping systems including fittings and accessories shall conform to ANSI B31.5-1966.

3.05 [Chemical Treatment Piping for Open and Closed Loop Piping Systems]

- A. Chemical treatment piping systems shall be selected and installed based on the recommendations of the chemical treatment contractor. Refer to specification 15545 for additional information.
- B. Where a fluid cooler water treatment by-pass loop is installed, all valves utilized in increasing system pressure shall be marked to identify position.
 1. Fluid cooler valves are not to be utilized to increase system pressure for the water treatment by-pass loop if the flow conditions to the fluid cooler cannot be maintained.
- C. All water treatment piping shall be schedule 40 black iron or schedule 80 CPVC. Return piping back to the system from brominators shall be schedule 80 CPVC.

3.06 [Emergency Generator Systems:]

- A. Exhaust: Install the muffler and flexible connection provided by the Electrical Contractor and furnish and install black steel pipe, exhaust pipe from the muffler to the outside as indicated on the Drawings. Coordinate requirements with the Electrical Contractor where packaged weatherproof outside units are specified.

3.07 Cleaning, Flushing, Testing, and Inspecting:

- A. Cleaning: Clean exterior surfaces of installed piping systems and prepare surface for application of any required coatings.
- B. Flushing: Flush piping systems with clean water prior to performing any required tests. All piping system flushing is to be conducted in a manner not to adversely affect the performance of the equipment connected to the piping system.
1. Flushing of Closed Loop Piping Systems:
 - a. All flushing shall comply with details in 15545, The supply and return runouts must be disconnected from each terminal unit or packaged unit and connected via a by-pass hose to allow circulation to the system, but not through the connected equipment. The system shall be chemically cleaned then flushed by opening the drain valve at the lowest point in the system. While the system is being drained, adequate make-up to the system will be provided to ensure the system remains full. With-in 24 hours after adequate and certification of system cleanliness by the chemical treatment contractor (refer to specification 15545 for additional requirements) the units shall be reconnected and an approved inhibitor shall be introduced to the loop.
- C. Piping Tests:
1. General: Blank off equipment during tests. Perform tests before piping is enclosed in walls, floors, partitions or in any other way concealed from view. Tests may be performed in sections. Tests shall be witnessed by VPTC Management Partners, LLC and local inspectors and the test results presented to VPTC Management Partners, LLC for acceptance and approval prior to concealing piping from view. Provide all necessary equipment for testing, including pumps and gauges. Note: All test results are to be submitted to VPTC Management Partners, LLC as specified in Section 15995.
 2. Heating Open Loop Condenser, Closed Loop Condenser, and Cooling Water System: Test water systems hydrostatically to a pressure of 150 psig or 1-1/2 times working pressure, whichever is greater, for a period of 4 hours. Repair all leaks, replacing materials as necessary, and repeat tests until systems are proven tight.
- D. Inspecting: Visually inspect each run of each system for completion of joints, adequate hangers, supports, and inclusion of accessories and appurtenances.
- E. Chemical Treating: Refer to Section 15545, "Water Treatment Systems", for additional requirements on flushing and cleaning of systems.
- F. Identification: Refer to Section 15190, "Mechanical Identification" for nameplates and labeling requirements.

END OF SECTION 15510

Section 15545 – Water Treatment

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, “General Requirements”, and Section 15010, “Basic Mechanical Requirements”, govern this Section.

1.02 Project Scope:

- A. This section includes the following:
 1. Water Treatment Open Loop Initial Setup
 2. Water Treatment Closed Loop Initial Setup
 3. Closed Loop Cleaning Washout Procedures
 4. Water Treatment Maintenance Program

1.03 Quality Assurance:

- A. Supplier: Water treatment chemical and service supplier who has been active in the field of industrial water treatment for not less than 5 years, and who has full-time service personnel located within trading area of the project.

1.04 Codes and Standards:

- A. Chemical Standards: Provide only chemical products which are acceptable under state and local pollution control standards.

Part 2 Products

2.01 Water Treatment Open Loop Initial Setup:

- A. Goal & Objectives: Provide a complete drumless chemical feed program using solid chemicals that will protect critical equipment and piping from deterioration due to corrosion and fouling of waterside surfaces while allowing this equipment to operate at optimum efficiency. Specific objectives are as follows:
 1. Provide protection of capital equipment for all hydronic systems within current industry corrosion guidelines; (NACE, AWT, ASHRAE, CTI)
 2. Utilize Certified Water Technologists (CWT) designated professionals to administer, supervise, and oversee the treatment program;
 3. Optimize efficiencies and energy consumption by maintaining clean, scale free surfaces;
 4. Reduce microbiological growth and potential bio-fouling;

5. Proactively test and treat for Legionella bacteria;
 6. Provide cost effective solutions for limiting exposure of chemicals to employees and operators.
 7. Choose chemistries that minimally impact the environment and are approved for discharge in accordance with Federal, State, and local ordinances.
- B. Equipment:
1. The following products and materials shall be provided by the water treatment consultant and installed by the mechanical contractor.
- C. Dual Solid Chemical Feed System:
1. The dual feed system shall house the cooling tower inhibitor and the secondary non-oxidizing biocide. The panel will require a ½" domestic water feed line for chemical mixing, 120 VAC power supply for fill/mixing valves, holding tank overflow piped to the nearest floor drain.
 2. Acceptable manufacturers: 21st Century & Advantage Controls Inc.
- D. Tower Microprocessor Chemical Controller:
1. The tower microprocessor chemical controller shall be capable of controlling:
 - a. Tower conductivity via conductivity monitoring and tower blow down via motorized ball valve or solenoid.
 - b. Tower cycles of concentration vial comparison to incoming make up water conductivity.
 - c. ORP monitor if the water treatment consultants program requires a constant oxidizing biocide residual
 - d. PH monitor and control if water characteristics require control of PH.
 - e. Non oxidizing biocide control via timer
 - f. Tower inhibitor control via water meter contact.
 2. The tower microprocessor shall at a minimum have the following options:
 3. Flow switch
 4. Temperature probe
 5. Local user control interface
 6. Open protocol communication to BAS via Modbus TCP/IP
 7. Run away chemical feed protection.
 8. Make up and blow down water usage data logging
 9. Spare I/O points for chemical feed totalization, chemical feed no flow alarming, etc.
- E. Acceptable manufacturers: Walchem, Advantage & Pulsafeeder

F. Corrosion Coupon Rack:

1. The corrosion coupon rack shall be schedule 80 CPVC and shall incorporate flow control valves, strainer, flow meter and two coupon sample ports: Copper and mild steel coupons shall be provided at the time of start up.
2. Acceptable manufacturers: Advantage Controls Inc. or equal

G. Separator:

1. For packaged cooling towers with integral cold water sumps, a **side stream separator** shall be provided sized to 10% of the condenser water pump design flow. The mechanical contractor responsible for the system design shall approve sizing.
2. For fluid coolers or systems with remote sump basins, an **independently pumped packaged separator** shall be provided sized to 1 GPM per square foot of sump area (verify with system manufacturer). The mechanical contractor responsible for the system design shall approve sizing. The packaged unit will include all necessary control equipment, sump spray nozzle, pump station, separator and drains. The controller shall be equipped with alarm points that can be reported to the building's BAS.
3. Acceptable manufacturers: Wingert or Lakos

H. Water Meters

1. Water meters shall be provided for make up and blow down. Both meters will be equipped with contact heads to provide usage feedback to the cooling tower controller.
2. The water treatment consultant shall verify with the mechanical contractor the size of the make up water line and provide a meter that is one size smaller than the make up line. The blow down meter shall be sized the same as the drain port of the side stream separator.
3. Acceptable manufacturers: Carlon or Master Meter

I. Brominator:

1. A brominator suitable for solid tablet feed shall be provided. The brominator shall include a pressure relief valve, solenoid valve, flow meter and two balancing/isolation valves. The brominator shall be sized so that refilling the unit is minimized to not more than monthly. In no case shall the brominator be sized at less than 25-pound capacity.
2. Acceptable manufacturers: Neptune or equal

J. Chemical Metering Pumps:

1. Two (1 for inhibitor and 1 for secondary biocide) diaphragm-metering pumps sized according to the chemical addition requirements and pressures with wetted parts being compatible with the chemical program shall be provided. Metering pumps shall have a minimum of 360:1 turndown with a digital display of pump speed. Each metering pump shall be fitted with a flow verification device that will confirm that the pump is metering chemical when it is actuated. The flow verification device shall be compatible with the multi I/O controller and allow for the totalization of chemical metered and through the multi I/O controller raise an alarm.
2. Acceptable manufacturers: Pulsafeeder, Advantage & Iwaki

K. Blow Down Valve:

1. A full-ported motorized ball valve shall be provided for installation on the drain of the side stream separator.
2. Acceptable manufacturers: Belimo or Clay

L. Miscellaneous:

1. The following miscellaneous items shall be provided by the water treatment consultant:
 - a. Pasivation/start up equipment and chemicals
 - b. Program control manuals
 - c. MSDS Sheets
 - d. Test kits and reagents
 - e. Standard solutions
 - f. Installation drawings for piping and wiring
 - g. Biocides, inhibitors, etc (90 day supply)
 - h. System commissioning
 - i. Operator training

M. Installation, System Start Up & Equipment Commissioning:

1. The water treatment consultant shall provide the following services to ensure that all equipment is properly installed, all metals are properly passivated and all equipment is properly started up and commissioned.
 - a. Pre-installation Meeting: will be held with the installing contractor, show that equipment locations can be discussed, installation drawings can be provided & reviewed, and all materials can be turned over for installation.
 - b. Pre-start Up Review Meeting: will be held to confirm proper and complete installation.
 - c. Start Up & Commissioning: The equipment shall be started up and checked for correct operation. All chemicals will be installed, mixing functions tested and controller will be set up.
 - d. Pasivation & Program Set Up: The water treatment consultant shall provide appropriate system passivation and set up the chemistry program once all equipment has been installed and commissioned.
 - e. Operator Training: provide a half day training session with the building operators after turnover has occurred. This training shall include a proper operation of all installed equipment, safety, chemical testing, daily logging, calibration, etc.

N. Chemical Treatments and New System Passivation:

1. The water treatment consultant must follow the cooling tower manufacturer's guidelines for recommended water chemistries as listed below. The vendor shall supply a monitoring (pH) and chemical feed system for use during the passivation process. This

process must be completed in accordance with the manufacturers specification prior to the cooling tower being put into operation. These startup guidelines are essential for prevention of white rust corrosion.

2. Baltimore Air Coil:
 - a. Passivation Treatment: Use of inorganic PO₄ treatment helps passivate zinc coating.
 - b. PH for initial service: 6.5-8.0
 - c. Hardness (as CaCO₃): > 30 PPM
 - d. General Comments: Avoid soft water, <30 PPM Ca, combined with higher alkalinity. Routine passivate if operating at a pH >8.3.
 - e. (Reference) Baltimore Aircoil Company. (1992) White Rust on galvanized steel cooling towers.
3. Evapco:
 - a. Passivation Treatment: 400-450 PPM Po₄ w/100 PPM Ca (as CaCO₃) for 45-60 days.
 - b. PH for initial/routine service: 6.5-8.0
 - c. Hardness (as CaCO₃): 100-300 PPM
 - d. Alkalinity (as CaCo₃): 100-300 PPM
 - e. Chlorides (as Cl): <250 PPM
 - f. Sulfates (as SO₄): <250 PPM
 - g. General Comments: Avoid soft water <50 PPM Ca as (CaCO₃). Avoid using acids. Routinely passivate if at a pH >8.3. Immediately clean and repassivate areas of white rust.
 - h. (Reference) EVAPCO (2002) White Rust. Engineering Bulletin No. 036.
4. Marley:
 - a. Passivation Treatment: Use inorganic PO₄ for at least 8 weeks to help passivate zinc coating.
 - b. PH for initial/routine service: 6.5-8.0
 - c. Hardness (as CaCO₃): 100-300 PPM
 - d. Alkalinity (as CaCo₃): 100-300 PPM
 - e. Chlorides (as Cl): <250 PPM
 - f. Sulfates (as SO₄): <250 PPM
 - g. General Comments: Avoid soft water. If purchase has not been made, consider stainless basin.
 - h. (Reference) Marley Cooling Tower Company (1992) White Rust & water treatment. Manual 92-1184A

O. Treatment (For non-aggressive make up water):

1. Inhibitor: Provide a concentrated solid corrosion/scale/fouling-inhibiting formulation containing molybdate (as a tracer), azole, polymers, and phosphonate without other materials in excess of allowable, local, effluent limits. The formulation must be suitable for the quality of the make up water so that the performance objectives can be met. Feed shall be automatic and maintained with the water treatment consultants published control ranges. The inhibitor package recommended shall be capable of maintaining (at the recommended cycles of concentration) the following:
 - a. Molybdenum: 1-3 ppm as Mo (to be used as a tracer)
 - b. Azole: minimum 1 ppm as available tolytriazole (TTA) or benzotriazole (BZT) (Available equals total azole minus 2 times the copper level).
 - c. Organic Phosphorus: 5 – 15 ppm as PO₄
 - d. Polymer: Minimum 10 ppm
2. The inhibitor product shall contain dispersants to control fouling and suspended matter.
3. Maintain system pH within a safe range to optimize corrosion control and to minimize the potential for scale and deposit formation
4. **Notes:**
 - a. **Orthophosphate-containing products shall not be used.**
 - b. **Chromate and/or Zinc-containing products shall not be used.**
5. Microbiocides:
 - a. The program must include a bromine based oxidizing biocide and a non-oxidizing biocide specific to Legionella and a dedicated biological penetrant and dispersant
 - b. Oxidizing Biocide: Solid Bromine briquettes, Great Lakes Hydantoin BCDMH or equal shall; be provided as the oxidizing biocide. This product shall be “shock fed” once daily at a rate that will achieve a residual of 1,0 ppm one hour after feed.
 - c. If a continuous halogen level is desired maintain 0.1 – 0.5 PPM as a maximum. This method shall also incorporate an ORP controller.
 - d. Non-Oxidizing Biocides: The secondary biocide shall be 98% active Solid DBNPA (Clearon C103G), shock fed weekly to maintain a 5 PPM residual. Water treatment consultant must show calculations for Holding Time Index, retention times, and blowdown rates to determine non –oxidizing biocide dosage rates. Biological testing via ATP is preferred, as “dip slide” media measure only aerobic organisms.
6. PH Control:
 - a. If PH control is required due to make up water characteristics, contact VPTC Management Partners, LLC’s Mechanical & Electrical Systems Manager for further information.

P. Installation Notes:

1. All installations shall be neat and all equipment shall be easy to access. All equipment shall be wall, stand or rack mounted. When possible, components will be mounted as a complete system on a 1/2" thick PVC panel suitable for wall mounting.
2. All downstream chemical injection lines shall be schedule 80 socket welded CPVC. All sample lines shall be sourced from a point that provides at least five gallons per minute at 60 psig and can overcome the pressure at the sample return point.
3. All electrical connections shall be hard wired. Any pump or controller cord sets shall not be extended to over three feet.

2.02 Water Treatment Closed Loop Initial Setup:

A. All closed loop systems shall be equipped with the following equipment:

1. Side Stream Pot Feeder: Each closed system shall have a five-gallon side stream pot feeder installed. The pot feeder shall be equipped with isolation valves on the inlet/outlet and a drain line piped to the nearest floor drain.
 - a. Acceptable Manufactures: Neptune, Vector or equal
2. Side Stream Filtration: Side stream filtration will be provided for each closed loop. When possible, this filtration shall reside at the lowest point of the system that will allow for adequate flow rates. The side stream filters shall be sized at 5 – 10% of the respective system's flow rate for the cleaning process of the primary chilled water and hot water recirculating systems. Filter vessel shall be made of 304L or 316L stainless steel, split shell construction with 316 stainless steel internals, brass vent, and stainless pipe plugs. The housing shall be equipped with a pressure gauge on the each of the inlet and outlet of the housing that are of appropriate pressure scale for the respective system. The vessel shall be equipped with isolation valves on the inlet/outlet and a drain line piped to the nearest floor drain. Filter vessels shall be suitable for operating pressures of 150 psi and operating temperatures of 200°F degrees. Filter media shall be wound propylene cartridges with steel cores. Filter cartridges shall have a nominal 30 micron rating. Flow rate per 10" length shall not exceed 6 GPM. Bag filter housings and filters will not be accepted!
 - a. Acceptable Manufactures: Mordock or equal
3. Corrosion Coupon Rack: Each closed loop system shall be equipped with a corrosion coupon rack. The corrosion coupon rack shall be schedule 80 CPVC and shall incorporate flow control valves, strainer, flow meter and two coupon sample ports: Copper and mild steel coupons shall be provided at the time of start up.
 - a. Acceptable manufacturers: Advantage Controls Inc. or equal

B. Chilled Water Treatment:

1. Molybdenum 100 PPM min. as MoO6 in chilled systems.
2. Azole (10 PPM)
3. ATP bacteria <300 r.l.u.'s, BIOTRACE or equal
4. pH – 8.5 – 9.5

C. Hot Water Closed Loop Systems:

1. Nitrite (1,000 PPM min. as NO₂),
 2. Azole (10 PPM)
 3. ATP bacteria <300 r.l.u.'s, BIOTRACE or equal.
 4. pH – 8.5 – 9.5
 5. Biocide additions may be necessary based on ATP results. Nitrite treated systems may breed nitrite reducing bacteria, i.e. nitrite is added constantly with little or no makeup. Oxidizing biocides are not recommended. Glycol percentages >25% will prevent biological growth.
- D. Inhibited Glycol Fluid Specifications (When applicable):
1. Refer to Section 15546 Anti-Freeze Heat Transfer Fluids for requirements.
- E. Installation Notes:
1. All installations shall be neat and all equipment shall be easy to access. All equipment shall be wall, stand or rack mounted.
 2. All electrical connection shall be hard wired unless a manufactured UL approved cord set is provided. No cord set shall be extended over three feet to the outlet.
 3. With the exception of the corrosion coupon rack, all closed loop components shall be piped in with materials of the same as the system it is connected to.

2.03 Closed Loop Washout Procedures

Vendor MUST verify and follow all OEM specifications for washout and cleaning.

- A. Vender shall have available:
1. Sufficient quantity of washout compound and Inhibitor.
 2. Chemical transfer or recirculating pump (if required).
 3. Protective gear (rubber gloves, protective face mask, rubber apron and all other personal protection equipment indicated by the washout procedure Material Safety Data Sheet, product bulletin and coding on the product label.
 4. Stainless steel cartridge filter vessel rated for appropriate temperatures and pressures.
- B. Washout Procedure:
1. Flush all “mud” legs and strainers thoroughly until only clear water runs out. Flush especially well all areas of low flow and low lying points of the circulating system. Install cartridge filter vessel and new 20 micron rated cartridges.
 2. Add the recommended amount of washout product to the system utilizing a chemical transfer or recirculating pump assembly. Product can be added to pot feeders or other suitable methods of product introduction may be used. Bring the system to full volume fresh, clean water. Maintain as high a temperature as possible, as this will facilitate cleaning of oils and greases. However; in no case should the temperature of the system exceed 200 F.

- a. NOTE: Some foaming may occur and is considered normal. Excessive foaming can be controlled by the addition of Anti-Foam. Add two (2) ounces of Anti-Foam to one (1) gallon fresh water.
 3. Add recommended dosage of washout treatment base on appropriate system volume and OEM specifications. (e.g. PRE CLN at 10 GLS. Per 1,000 gallons system volume) Circulate throughout the system, being sure that all that sections of the piping system are open to full flow and all tube bundles, condenser coils and plate & frame heat exchange equipment are **bypassed**. Cleaning duration at full flow should be a minimum of six (6) hours and a maximum of twenty-four (24) hours or until the cleaning is completed. Change cartridge filters as needed to facilitate cleaning.
 4. Remove filters from vessel and connect fresh water makeup via hydrant to the CWR somewhere at the top of the system and connect drain hose on the CWS somewhere near the bottom of the system.
 5. Flush system thoroughly while draining until water treatment vendor verifies washout compound is removed.
 6. Immediately following completion and verification of flushing, certification records covering the cleaning operation shall be submitted to necessary parties. Water treatment vendor will collect a final retain sample. Vendor to document flushing is completed by testing water to insure conductivity is within 25 mmho's of incoming makeup source and Total "M" alkalinity is also within 25 PPM of makeup source.
 7. Within 24 hours of cleaning procedure and acceptance the loop will be filled with USP Propylene glycol (when applicable) and inhibitor package. Water Treatment vendor to verify glycol (when applicable) and inhibitor concentrations within 48 hours of glycol circulation.
- C. Acceptable Closed System Treatment Program:
1. Primary treatment is for corrosion and microbiological attack. Scale control may be an issue if large amounts of hard water makeup are introduced. Systems that typically take on more than 2,000 gallons of makeup per year should utilize a water softener.
 2. Supply sufficient quantity plus 25% to provide the following levels:
 - a. Chilled & Condenser Water Treatment
 - 1) Molybdenum 100 PPM min. as MoO₆ in chilled or condenser water systems.
 - 2) Azole (10 PPM)
 - 3) ATP bacteria <300 r.l.u.'s, BIOTRACE or equal
 - 4) pH – 8.5 – 9.5
 - b. Hot Water Closed Loop Systems
 - 1) Nitrite (1,000 PPM min. as NO₂),
 - 2) Azole (10 PPM)
 - 3) ATP bacteria <300 r.l.u.'s, BIOTRACE or equal.
 - 4) pH – 8.5 – 9.5

- 5) Tolytriazole (TT) yellow metal corrosion inhibitors should be reported “as available”, meaning dosage minimums must be determined as total Azole minus two times the system copper levels. Copper levels should be below 0.2 PPM at all times.
- c. Biocide additions may be necessary based on ATP results. Nitrite treated systems may breed nitrite reducing bacteria, i.e. nitrite is added constantly with little or no makeup. Oxidizing biocides are not recommended. Glycol percentages >25% will prevent biological growth.
- d. Testing for iron levels (<1.0 PPM) is recommended. Corrosion control via Steel coupons (<0.5 MPY), Copper coupons should show (<0.08 MPY).

2.04 Cooling Water Treatment Maintenance Program

A. Scope of Services

1. Each of the items outlined below shall be provide under an annual contract with fixed costs. Vendor will provide fixed costs for these services when submitting the proposal for the initial plant set up. The annual cost of this contract shall be divided by four and billed quarterly.

B. Routine Visits

1. During the primary cooling season the water treatment consultant shall visit the site no less than twice per month. During the off season, the consultant shall visit the site no less than once per month

C. Routine Testing (Water Treatment Consultant)

1. Each Visit:
 - a. During each routine visit the water treatment consultant shall conduct appropriate water analysis of the cooling and make up water to insure proper treatment.
 - b. Review the operator’s daily log to insure proper program maintenance by VPTC Management Partners, LLC staff members.
 - c. Check for the correct operation of all water treatment systems and equipment.
 - d. Troubleshoot water treatment related problems.
 - e. Recommend/make all necessary corrections/adjustments.
 - f. Provide additional training/consulting as required.
 - g. Provide a written report of test results, recommendations, and adjustments. One copy of the report shall be left with the on-site engineer and a second copy shall be sent to the Operations Manager.
2. Quarterly:
 - a. To insure the water treatment program is properly controlling Legionella, each quarter the water treatment consultant shall collect water samples for each open system and send these samples to an independent laboratory for analysis. The results of these analyses shall be submitted to the on -site engineer and the Operations Manager.

These submittals shall include a summary from the consultant, necessary corrective actions, and the independent laboratory reports.

- b. Each quarter the consultant shall remove all corrosion coupons from each system and send them to an independent laboratory for analysis. The results of these analyses shall be submitted to the on- site engineer and the Operations Manager. These submittals shall include a summary from the consultant, necessary corrective actions, and the independent laboratory reports.
3. Annually:
- a. The water treatment consultant shall visit the site to inspect any cooling towers, chillers, and heat exchangers that are taken off line for cleaning/maintenance. A report of the findings as well as necessary corrective actions will be left with the on site engineer and one copy will be sent to the Operations Manager.
 - b. If a system contains glycol, the water treater shall analyze the freeze protection levels. Glycol shall be maintained at 40% of the system volume with a freeze protection of – 13 degrees Fahrenheit.

D. Program Control

1. The treatment program shall meet or exceed the standards set by NWT, ASHRAE, BOMA, and NACE.
2. The open systems shall be treated with a concentrated solid corrosion/scale/fouling-inhibiting formulation containing molybdate (as a tracer), azole, polymers, and phosphonate without other materials in excess of allowable, local, effluent limits. The formulation must be suitable for the quality of the make up water so that the performance objectives can be met. Feed shall be automatic and maintained with the water treatment consultants published control ranges for scale and corrosion. The inhibitor package recommended shall be capable of maintaining (at the recommended cycles of concentration) the following:
 - a. Molybdenum: 1-3 ppm as Mo (to be uses as a tracer)
 - b. Azole: minimum 1 ppm as available tolytriazole (TTA) or benzotriazole (BZT) (Available equals total azole minus 2 times the copper level).
 - c. Organic Phosphorus: 5 – 15 ppm as PO4
 - d. Polymer: Minimum 10 ppm
3. The systems shall be treated for biological control using a combination of oxidizing and non-oxidizing products. Solid Bromine briquettes, Great Lakes Hydantoin BCDMH or equal shall; be provided as the oxidizing biocide. This product shall be “shock fed” once daily at a rate that will achieve a residual of 1.0 ppm one hour after feed. If a continuous halogen level is desired maintain 0.1 – 0.5 PPM as a maximum. This method shall also incorporate an ORP controller. The secondary biocide shall be 98% active Solid DBNPA (Clearon C103G), shock fed weekly to maintain a 5 PPM residual.
4. The treatment program shall be designed to insure efficient operation of all heat transfer/rejection systems. Cooling towers systems shall be run at >4.5 to 5.0 cycles of concentration or 1000-1200 MMHOs depending on the make up water chemistry. The water treatment consultant shall perform annual efficiency studies to each system and make adjustments as required.

5. Those open systems that are left on line during the winter (low flow months) shall be adjusted and controlled to provide proper corrosion and bacteria treatment. The consultant shall insure that the on site staff is properly instructed on the methods of control during the low flow months.
6. Closed systems shall be maintained at the following levels:
 - a. Molybdenum 100 PPM min. as MoO₆ in chilled systems.
 - b. Nitrite (1,000 PPM min. as NO₂),
 - c. Azole (10 PPM)
 - d. ATP bacteria <300 r.l.u.'s, BIOTRACE or equal.
 - e. pH – 8.5 – 9.5
 - f. **Note:** Biocide additions may be necessary based on ATP results. Nitrite treated systems may breed nitrite reducing bacteria, i.e. nitrite is added constantly with little or no makeup. Oxidizing biocides are not acceptable.
 - g. **Note:** chemical additions to closed loops that are considered “maintenance” shall be part of the annual contract. Large dose additions VPTC Management Partners, LLC to drain downs, etc, are not part of the contract and shall be invoiced separately.
7. Mild steel corrosion levels shall be maintained at <2 mpy on open systems and <.5 mpy on closed systems. Yellow metal corrosion levels shall be maintained at <.3 mpy on both open and closed systems.
8. System Copper levels shall be below 0.2 PPM at all times.
9. If a system contains glycol, the levels shall be maintained to provide freeze protection to – 13 degrees Fahrenheit. **Note:** glycol additions are not included in the annual contract pricing, these shall be invoiced separately.

E. Products/Materials

1. The water treatment consultant shall provide all chemicals necessary to properly treat the cooling system including Water Chillers, Cooling Towers, Remote Sumps, Heat Exchangers, Boilers, and open/closed loop piping. The water treatment consultant will provide all test kits, calibration “standard” solutions, reagents, Agar slides (Biological control performance), and corrosion coupons.
2. The water treatment consultant shall provide repair, maintenance, and replacement of any control or feed equipment at an additional cost to the annual contract.
3. The water treatment consultant will provide all daily test log sheets, program control manuals, product sheets, and MSDS sheets.

END OF SECTION 15545

Section 15610 – Forced Air Furnaces

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Provide self-contained, high efficiency, indirect gas-fired warm air furnaces, as specified.

1.03 Quality Assurance:

- A. Provide central furnaces constructed, tested and rated in accordance with ANSI Z21.47, Gas-Fired Central Furnaces.
- B. Provide furnaces that are AGA certified. Gas train shall be IRI/FM approved.
- C. Provide a twenty-year material warranty on the gas-fired heat exchanger.

1.04 Submittals:

- A. Shop drawings submittals shall include, but are not limited to, the following:
 - 1. Unit cutsheets clearly showing all features, accessories, dimensions, weights, and capacities.
 - 2. Written instructions for equipment to installation.
 - 3. Wiring and piping diagrams and connection locations.
 - 4. Performance certifications and test results.
 - 5. Warranty information.
 - 6. Additional information as required in Section 15010.

Part 2 Products

2.01 Manufacturers:

- A. Armstrong
- B. Bryant Heating & Cooling, Indianapolis, IN
- C. Carrier Air Conditioning, Syracuse, NY
- D. Goodman Manufacturing Company

- E. Rheem/Rhud
- F. Trane
- G. York

2.02 Equipment:

- A. Provide furnaces with fan, motor and drive, gas-fired heat exchanger, and other components as indicated.
- B. Casing:
 - 1. Galvanized Steel: Enamel finish
 - 2. Removable access panels for service
 - 3. Fiberglass insulated heat exchanger section
 - 4. Horizontal or upflow.
- C. Fans: Multi-speed direct drive motor.
- D. Burner:
 - 1. Sealed combustion, natural gas burner
 - 2. Minimum 92% combustion efficiency
 - 3. One piece primary heat exchanger
 - 4. Stainless steel secondary heat exchanger
 - 5. Redundant, automatic gas valve controls
- E. Air Filters: 1" Throwaway, minimum MERV 6 efficiency.
- F. Controls:
 - 1. Microelectronic controller with self diagnostics
 - 2. Hot surface ignitor
 - 3. Flame sensor
 - 4. High temperature limit shutoff
 - 5. Control transformer
- G. Auxiliary Cooling Coil: Style A - Type DX.

Part 3 Execution

3.01 Installation

- A. Install furnace in accordance with manufacturer's recommendations.

- B. Provide service clearances around each furnace per Section of the International Mechanical Code.
- C. Route combustion air intake piping and flue piping per manufacturer's specifications.

END OF SECTION 15610

Section 15675 – Air-Cooled Condensing Units

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Provide air cooled condensing units (compressors and condensers) coupled to direct expansion (DX) refrigerant coils for air conditioning applications, as specified.
- B. Work of Other Sections: Section 15680 "Split System Fan Coil Units" ..

1.03 Quality Assurance:

- A. Provide condensing units constructed, tested and rated in accordance with ARI 240-2006, "Performance Rating of Unitary Air Conditioning and Air Source Heat Pump Equipment" for units 5 Tons and less, and ARI 340/360-2007, "Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment" for units 6 to 10 Tons in capacity.
- B. Refrigeration system installation and components shall comply with ASHRAE 15, Safety Code for Mechanical Refrigeration.
- C. Provide condensing units that are UL labeled and listed.
- D. Provide refrigeration compressors with a full manufacturer's warranty for five years from date of start-up.

1.04 Submittals:

- A. Shop drawings submittals shall include, but are not limited to, the following:
 - 1. Unit cut-sheets clearly showing all features, accessories, dimensions, weights, and capacities.
 - 2. Written instructions for equipment to installation.
 - 3. Wiring and piping diagrams and connection locations.
 - 4. Performance certifications and test results.
 - 5. Warranty information.
 - 6. Additional information as required in Section 15010.

Part 2 Products

2.01 Manufacturers:

- A. Carrier Air Conditioning, Syracuse, NY
- B. Goodman Manufacturing Company
- C. Trane Company
- D. York

2.02 Condensing Units:

- A. General: Provide factory assembled, air cooled condensing units consisting of hermetic compressor and motor; condenser coil, fan and motor; refrigerant system components and operating controls as shown and scheduled on the Drawings.
- B. Match capacities of condensing units with associated evaporator units and provide both units from same manufacturer.
 - 1. Unit Frame: Frame shall be a welded assembly of heavy gauge zinc-coated, galvanized steel. Drainage holes shall be provided as required. Exterior surfaces shall be cleaned, phosphatized and coated with an epoxy resin primer and finished with an enamel finish.
 - 2. Refrigeration Circuits: Units up to 5 tons shall have single compressors with a single compressor. Units 6 tons and larger shall have dual compressors and dual refrigerant circuits for use with a dual circuit cooling coil. Each refrigeration circuit shall have an integral subcooling circuit.
 - 3. Compressors: Each compressor shall be a direct-drive hermetic type with centrifugal oil pump; two-point lubrication for each bearing and connecting rod; crankcase heater and well; high strength, ring-type suction and discharge valves; large gas passages and minimum clearance volumes; and rubber-in-shear isolators; and a thermostatically controlled crankcase heater.
 - 4. Compressor Motors: Each compressor motor shall be suction gas-cooled and have a voltage utilization range of plus or minus 10 percent of nameplate voltage. Internal temperature and current-sensitive motor overloads shall protect compressors under loss of charge and other abnormal operating conditions.
 - 5. Condenser Fans: Fans shall be vertical discharge, direct-drive type, statically and dynamically balanced, with aluminum blades and zinc-plated steel hubs. Motors shall have permanently lubricated ball bearings, built-in current and thermal overload protection and weathertight slingers over bearings. The fan motors shall be mounted in rubber isolators. Corrosion resistant fan grills shall be provided.
 - 6. Condenser Coils: Condenser coils shall be configured aluminum fins mechanically bonded to seamless copper tubing. Subcooling circuit(s) shall be provided as standard for each refrigeration circuit. Coils shall be factory pressure and leak-tested to 425 psig air pressure. Corrosion resistant metal grilles for coil protection shall be provided.
 - 7. Refrigerant Line Connections: Connections shall be either compression or sweat type. Brass liquid and suction line service valves, gauge/charging ports in the liquid line and a sight glass in the liquid line shall be provided.

8. Refrigerant/Oil Charge: Units shall be shipped from the factory with a sufficient charge of R-134a refrigerant and oil for the complete system when used with pre-charged refrigerant lines.
9. Controls: Unit controls shall include a fused voltage appropriate control power transformer, magnetic contactors for each compressor, cooling low ambient fan switches, high pressure cut-out(s), low pressure cut-out(s) and reset relays. Unit completely factory-wired with necessary controls and terminal block for connection of field control power wiring. An anti-recycle timer shall be provided. If building is equipped with a building automation system (BAS), refer to specification Section 15950. If being installed into a building without a BAS or if equipment is for a computer room, provide an accessory programmable thermostat complete with an electronic programmable night setback, separate automatic heat/cool settings, auto/manual fan control and seasonal selector. Thermostat shall provide staging of the cooling and heating to match the stages of each component
10. Low Ambient Operation: On applications requiring year-round cooling, units shall include necessary controls to allow starting and operation down to 0°F.
11. Warranty: The manufacturer's one year parts and labor and five year extended (non pro-rated) compressor warranty shall be provided.

Part 3 Execution

3.01 Examination:

- A. Examine areas and conditions under which condensing units are to be installed.
- B. Do not proceed with work until satisfactory conditions are present.

3.02 Installation:

- A. Interface With Other Products:
 1. Coordinate installation of units with structure and roofing materials. Provide mechanical equipment support curbs under each side of unit in accordance with Section 15140 and attach at each corner of unit. Provide supplemental framing beneath curbs as required by project structural engineer.
 2. Coordinate installation of units on grade with building landscaping elements, maintaining required minimum airflow clearance. Provide 4" concrete housekeeping pad beneath each unit.
 3. Coordinate roof opening locations and pipe curbs for mechanical and electrical connections.
- B. Install in accordance with manufacturer's instructions.
- C. Provide equipment rigging in accordance with manufacturer's instructions and lift to rooftop location.
- D. Provide additional support steel necessary for complete installation.

- E. Provide adequate clearance from other equipment for proper airflow, as well as for maintenance and service.
- F. Make sure roof surface is protected at all times during installation, make sure proper padding is installed under unit so not to void roof warranty. Use qualified roofing contractor as specified by building owner.

3.03 Demonstration:

- A. Provide services of manufacturer's factory trained field engineer for leak testing, charging, installation supervision and initial start-up of equipment, including coordination for start-up of all related controls and other equipment. Provide reports showing all pertinent data (pressures, temperatures, etc.).
- B. Installer to advise equipment manufacturer at least 10 days prior to time field engineer is required, furnish sufficient manpower to perform work, and schedule related trades for installation and start-up.
- C. Provide services of manufacturer's engineer at time of start-up to instruct Owner and his operating personnel in proper care and operation of equipment.

END OF SECTION 15675

Section 15680 – Split System Fan Coil Units

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Provide a UL listed split system fan coil units including, but not limited to, the furnishing and installation of an indoor evaporator unit, filter racks, supply fan, electric heat section, thermostat, accessories and other controls as required by local, state, and other applicable codes.

1.03 Quality Assurance:

- A. Manufacturer: Provide products of one of the following:
 - 1. Carrier Air Conditioning
 - 2. Trane Company
 - 3. York
- B. Certification: Provide manufacturer's certification of compliance with ARI Standard 440-2005 "Performance Rating of Room Fan Coils".

1.04 Submittals:

- A. Shop drawings submittals shall include, but are not limited to, the following:
 - 1. Unit cutsheets clearly showing all features, accessories, dimensions, weights and capacities.
 - 2. Written instructions for equipment to installation.
 - 3. Wiring and piping diagrams and connection locations.
 - 4. Performance certifications and test results.
 - 5. Warranty information.
 - 6. Additional information as required in Section 15010.

1.05 Product Delivery, Storage and Handling:

- A. Deliver split system fan coil units and accessories in factory-fabricated water-resistant wrapping.

- B. Handle split system fan coil units and accessories carefully to avoid damage to material components, enclosure and finish.
- C. Store split system fan coil units and accessories in a clean, dry space and protect from the weather.

Part 2 Products

2.01 Materials:

- A. General: Except as otherwise indicated, provide split system manufacturer's standard materials and components as indicated by his product information, designed and constructed as recommended by the manufacturer and as required for a complete installation.
- B. Fan Coil Units:
 - 1. General: Provide fan coil units of the size and capacity scheduled on the Drawings. All units shall be UL approved and rated in accordance with AIR Industry Standard 441.
 - 2. Basic Unit: Units shall be fabricated of 18 gauge galvanized steel. The fan and motor assembly shall be easily removable for service. Units shall have 1" supply and return duct collars.
 - 3. Cabinet: Cabinets shall be horizontal enclosed type and shall have 18 gauge steel panels acoustically and thermally insulated with 1/2" coated glass fiber insulation meeting NFPA-90A and Hospital Code requirements. Exposed panels shall be bonderized and finished with a baked primer and a finish coat of enamel.
 - 4. Coils: DX cooling coils shall have copper tubes with aluminum fins, mechanically bonded to the tubes. Coils for use with single compressor condensing units shall be single circuit and coils for use with dual compressor condensing units shall have two full-face refrigerant circuits. A factory installed thermal expansion valve shall be provided for each circuit. "A" coils shall be factory leak tested at 225 psi air under water. Coils shall have a maximum of 12 fins per inch. Coil air pressure drop shall not exceed scheduled maximum.
 - 5. Optional Electric Heat Section: Electric heating coils shall be integrally mounted and shall have voltage and capacity as scheduled. Heater elements shall be constructed of heavy-duty nickel chromium wire. Heaters shall be complete with magnetic contactor and all required controls and safeties.]
 - 6. Motors: Motors shall be 3-speed, high efficiency, permanent split capacitor type with thermal overload protection. Maximum motor horsepower, input wattage shall not exceed that schedule.
 - 7. Junction Box: Units shall have a factory installed junction box with the fan motor and electric heating coil wired to the junction box for single point connection.
 - 8. Fans: Fans shall be of the centrifugal, forward-curved type. Fan wheels shall be statically and dynamically balanced. Fan wheels and housings shall be galvanized steel.
 - 9. Drain Pan: Pans shall be fabricated of 18 gauge galvanized steel lined on the interior surfaces with 1/2" fire retardant closed cell foam. A 7/8" OD sweat fitting shall be

provided for primary drain connection. A 1/2" OD overflow secondary drain connection shall be provided. Units shall be provided with a pan extension under the piping area.

10. Auxiliary Drain Pan: An auxiliary drain pan shall be installed under each fan coil unit as required by the Mechanical Code.
11. Filters: Filter shall be 1" pleated with a MERV 6 minimum efficiency and shall be installed in each unit. Return air opening shall be a [rear] [bottom] mounted grill or duct connection as shown on the drawings. Three sets of filters shall be supplied for each fan coil units. One set shall be installed at initial unit startup after all ductwork has been blowout and shall be used during balancing and testing, the second set shall be installed at the time of substantial completion and the third set shall be turned over to the Owner. Any additional filter sets required during the construction period shall be the responsibility of the Contractor.
12. Certification: All fan coil unit performance data shall be certified in accordance with ARI 440-2005.
13. Unit Controls: Controls shall include a magnetic fan contractor, terminal strip [heater contactor and controls] and all other required controls. All controls shall be factory wired and tested.

C. Duct Mounted DX Cooling Coils:

1. General: Provide duct mounted DX cooling coils of the size, type, capacity and arrangement as shown and scheduled on the Drawings.
2. Coils: Coils shall consist of aluminum plate fins mechanically bonded to copper tubes. Coils for use with single compressor condensing units shall be single circuit and coils for use with dual compressor condensing units shall have two full-face refrigerant circuits. A factory installed thermal expansion valve shall be provided for each circuit. Coils shall be factory leak tested at 225 psi air under water. Coils shall have a maximum of 12 fins per inch. Coil air pressure drop shall not exceed scheduled maximum and the coil shall be selected to match the condensing unit that serves it.
3. Casing: The coil shall be encased in a painted galvanized enclosure with an integral drain pan with primary and auxiliary drain connections. The casing shall have refrigerant line connections and duct flange connections as required.
4. Auxiliary Drain Pan: An auxiliary drain pan shall be installed under each duct mounted cooling coil.

Part 3 Execution

3.01 Installation:

- A. General: Install each system in accordance with manufacturer's instructions, the NEC, and applicable local codes and ordinances. Test installed system for compliance with these Specifications. Rework as required and as directed to ensure that specified and indicated requirements are met and that installed systems function as intended.
- B. Mounting: Provide foundation, platforms, and hangers required for proper installation of equipment. Fan Coil unit to be located inside the area it is serving over the swing of the door for servicing access.

- C. Fans: Install fans to operate without noticeable vibration or noise after installation. Refer to specification Section 15240.
- D. Guards: Arrange belt guards to permit accessible tachometer readings, oiling, and testing with guards in position.
- E. Refrigerant Piping: Install, test, evacuate and charge refrigerant piping per the manufacturer's recommendations. Technician performing this work shall be certified and shall utilize proper refrigerant reclaim procedures.
- F. Identification: Refer to Section 15190, "Mechanical Identification", for applicable painting, nameplate, and labeling requirements. Nameplates on units in finished areas shall be installed inside the unit cover and the unit manufacturers labeling system shall be used for exposed labeling of units.

END OF SECTION 15680

Section 15855 – Packaged Roof Top Units

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Provide packaged roof top air conditioning units, complete with controls and accessories as specified. Units shall be constant volume or variable volume airflow as required by project application.
- B. Roof curbs are furnished under this section. Coordinate installation of curbs with Roofing Contractor.
- C. Units shall be self-contained, rooftop curb-mounted, single package type. The rooftop units shall be completely factory assembled as a unitary package complete with operating controls and shall be completely piped, internally wired and fully charged with R-134a or R-410a refrigerant. Only one electrical power connection shall be required.
- D. Provide a complete installation of the units including startup, air balancing and functional testing to confirm proper operation. Copies of the start up report, air balance report and functional tests shall be included in the operations and maintenance manuals.

1.03 Quality Assurance:

- A. Energy Efficiency Ratio and Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings".
- B. Equipment shall be installed and wired in accordance with applicable local and national codes.
- C. Unit shall conform to the requirements and specifications of NFPA, and applicable local, state, and national codes.
- D. Units shall be warranted by manufacturer with full factory warranty on materials and workmanship for one year from date of start-up, or the date of beneficial use, whichever is later.
 - 1. Special Warranty: A written warranty, executed by the manufacturer and signed by the Contractor, agreeing to replace components that fail in materials or workmanship, within the specified warranty period, provided manufacturer's written instructions for installation, operation, and maintenance have been followed.
 - a. Warranty Period. Compressors: Manufacturers standard, but not less than 5 years after date of Substantial Completion.
 - b. Warranty Period. Heat Exchangers: Manufacturers standard, but not less than 10 years after date of Substantial Completion.

- E. The start up of the unit shall be completed by a factory certified technician.

1.04 Submittals:

- A. Shop drawings submittals shall include, but are not limited to, the following:
 - 1. Unit cutsheets clearly showing all features, accessories, dimensions, weights, and capacities.
 - 2. Written instructions for equipment installation.
 - 3. Wiring and piping diagrams and connection locations.
 - 4. Performance certifications and test results.
 - 5. Warranty information.
 - 6. Additional information as required in Section 15010.

Part 2 Products

2.01 Manufacturers:

- A. Rooftop HVAC units shall be as manufactured by one of the following:
 - 1. Carrier Corp.
 - 2. Trane Co.

2.02 Rooftop Units:

- A. Description: Factory assembled and tested and consisting of compressor, condensers, evaporator coils, condenser and evaporator fans, refrigeration and controls, filters, and dampers.
- B. Casing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, removable panels or access doors with neoprene gaskets for inspection and access to internal parts, minimum 1/2-inch thick thermal insulation, knockouts for electrical and piping connections, exterior condensate drain connection, and lifting lugs.
- C. Evaporator Fans: Forward curved, centrifugal single or double width with permanently lubricated motor bearings. Direct drive for units 6 Tons and smaller. Belt drive with adjustable sheaves for units 7.5 Tons and larger. Fan shall be statically and dynamically balanced and tested in the factory. Fan shall not pass through its first critical speed to meet its scheduled performance. Motors shall be thermally protected.
- D. Condenser Fans: Vertical discharge, propeller type, directly driven, statically and dynamically balanced in the factory with permanently lubricated motor bearings and thermal overload protection and be protected by a wire guard.
- E. Refrigerant Coils: Aluminum-plate fin and seamless copper tube in galvanized steel casing with equalizing-type vertical distributor. Coils shall be leak tested at the factory to 200 psig and pressure tested to 450 psig.

1. Unit shall be equipped with factory-supplied condensate drain connection for evaporator coil.
 2. Unit shall be provided with hail guards.
- F. Compressors: Hermetic with integral vibration isolators and crankcase heater. Compressor motors shall be cooled by suction gas passing through motor winding and shall have internal thermal overload protection.
1. Provide factory-installed crankcase heater, automatic reset type high and low pressure controls, high motor temperature cut-out, overcurrent and three phase overload protection, and anti-cycle timer.
 2. Unit shall be capable of starting and running at 115°F ambient outdoor temperature per maximum load criteria of ARI Standard 360.
 3. Provide low ambient head-pressure control, designed to operate at temperatures as low as 30 deg F
 4. Refrigerant circuit components shall include filter dryers, liquid line sight glasses, compressor discharge valves, liquid line service valves and thermal expansion valves.
- G. Electric Heat: Electric heating sections shall be furnished with nickel-chromium open coil resistance heating elements with each element protected by a primary automatic reset high-limit thermostat and secondary manual reset high-limit thermostat for the overcurrent/thermal protection. Electric heating section shall be UL listed
- H. Filter: Standard filter section shall consist of low velocity, disposable pleated filters in commercially available sizes. Provide 1" filters for units 6 Tons and smaller and 2" filters on sizes 7.5 Tons and larger. Filters shall be not less than 30% efficient when tested in accordance with ASHRAE Standards. Temporary filter media shall be provide throughout the course of construction and shall be changed as required to maintain proper unit operation and filtration. Provide new set of filters when building is turned over to VPTC Management Partners, LLC.
- I. Integrated Economizer: Units shall be provided with full economizer capability as required by Section 6.5.1 of ASHRAE 90.1-2004 based upon geographical climate. When required, provide enthalpy controlled integrated type consisting of dampers, motors and linkages, and potentiometer in conjunction with control system to provide primary cooling using outdoor air, enthalpy permitting, supplemented with mechanical cooling when necessary.
1. Dampers shall be low-leakage type, not to exceed one percent leakage at one inch water gauge pressure differential when fully closed.
 2. Linkages shall have spring return feature which shuts dampers upon power interruption or unit shutdown.
 3. Capable of introducing up to 100% outside air.
- J. Exhaust/Relief: Provide barometric relief damper on units 6 Tons and smaller. On units 7.5 Tons and larger provide, forward curved, centrifugal exhaust/relief fans, capable of 100% of maximum economizer air flow, with belt driven adjustable sheaves or with optional factory installed variable frequency drive for capacity control. Fan shall be controlled by building pressure sensor for active pressure control.

- K. Electrical: All unit power wiring shall enter cabinet at single location for single point connection. Provide factory wired 115-V, AC fused outlet, separately fused, located in unit cabinet.
1. All 3-phase compressor and fan motors shall be protected against overcurrent and single phasing conditions. Protection devices shall be manual reset type.
- L. Controls:
1. Controls shall be accomplished through use of factory installed, microprocessor based control system and associated electronic and electrical hardware.
 2. For buildings with BAS (Building Automations System) the units shall be provided with a Lon Certified Controller controller. All applicable LONMark points shall be made available through the BAS system.
 3. For buildings which do not have a BAS, provide staged heating and cooling thermostat with manual or automatic changeover on standard subbase.
- M. Roof Curb:
1. Each unit shall be provided with a full perimeter roof curb. The roof curb shall be of the same manufacturer as the unit, shall support the unit and provide a watertight enclosure to protect ductwork and utility services. Curb design shall comply with National Roofing Contractors Association requirements. Supply/return air opening gasketing shall be provided. Channel shall be provided allowing for adjustment of return air opening location to match the building structural frame indicated.
 - a. For rooftop units of 50 tons or greater, provide isolation rails for vibration isolation and install sound attenuation materials inside the roof curb to dampen noise transfer from unit to occupied space. Vibration rails shall have rigid upper and lower steel structure with vibration isolation springs and vertical and horizontal restraints; with elastomeric waterproof membrane and 2-inch static deflection Coordinate added weight with structural engineer.

2.03 Requirements for Rooftop Units Larger than 25 Tons:

- A. In addition to the standard features for Rooftop Units, units with 25 Tons and greater cooling capacity shall include the following:
1. Lifting lugs to facilitate overhead rigging.
 2. Unit cabinet shall be constructed of heavy gauge galvanized steel, 1" double wall construction (18 gauge exterior and 20 gauge interior) with welded base assembly. The interior surfaces shall be coated with rust inhibiting paint. All panels and covers shall be insulated with 1 inch, one pound density matt faced, fire resistant, permanent, odorless, fiber glass insulation.
 3. Multiple semi-hermetic or scroll type compressors and capable of at least four stages of loading. Compressors shall be factory mounted on spring vibration isolators.
 - a. Coils shall be interlaced circuited to provide independent refrigeration systems.
 4. The fan and motor assembly shall be mounted on a common base. For units with motor sizes greater than five (5) HP, the entire assembly shall be internally isolated from the rest of the unit with double deflection vibration isolators. Motors shall be thermally protected.

2.04 Variable Volume Rooftop Unit Requirements:

1. Supply fan shall be provided with variable speed frequency drives as specified in specification section 15080. Matching high-efficiency motors shall be provided on fans.
2. Provide air flow monitor across outside air damper to monitor minimum ventilation airflow in compliance with Section 5 of ASHRAE Standard 62.1-2004.
3. Hot-gas bypass shall be provided on refrigeration system of all variable air volume (VAV) units.

Part 3 Execution

3.01 Equipment Set-up, Configuration, Check-Out and Building Automation System Integration

- A. All controller setup/configuration required to meet the operating and control requirements of the specifications are to be performed at the factory. Any controller setup/configuration required for proper operation of the equipment that is not performed at the factory is to be performed in the field by the equipment supplier. This includes any field setup/configuration/wiring changes required to have the controller meet the specified sequence of operation and integration requirements.
- B. Equipment supplier to provide documentation listing all of the data points for his equipment, including data point name, data point type and description of the data point's function.
- C. Equipment supplier to provide 16 hours of on-site technical support for data integration/verification between the equipment manufacturer's open protocol controller and the Building Automation System. Equipment supplier's on-site technical support person to be factory trained and certified in the configuration, operation, checkout and troubleshooting of the equipment manufacturer's open-protocol controller.
- D. Equipment supplier is responsible for any and all ancillary warranty work associated with the repair/replacement of its defective open protocol controllers. This includes, but is not limited to, repair/replacement of defective open protocol controllers, setup/configuration of repaired/replaced defective controllers, re-integration into the Building Automation System, etc.
- E. Equipment Supplier, Temperature Controls Contractor, and HVAC Contractor and VPTC Management Partners, LLC shall meet before equipment is installed to discuss all equipment installation.

3.02 Start-Up:

- A. A factory certified trained service technician shall complete the start-up.
- B. A factory certified service technician shall fully instruct Owner's personnel in the operation and maintenance of units.

3.03 Installation:

- A. Install units on roof curbs furnished by unit manufacturer and in accordance with manufacturer's installation instructions.

- B. The rigging and setting of the units shall be in accordance with the unit manufacturer's recommendations. The unit manufacturer shall supervise the rigging and setting of these units where requested by VPTC Management Partners, LLC.
- C. All penetrations through unit are to be in factory provided chases. No penetrations through the condensate pan, etc. are permitted.
- D. Interlocks shall be made to the duct-mounted smoke detectors in each units return ductwork to shut the unit off and fully close the return air dampers to prevent migration of smoke upon its detection.

END OF SECTION 15855

Section 15891 – Ductwork and Accessories

Part 1 - General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included:
 - 1. Provide sheet metal ductwork and accessories as specified herein.
- B. Types: The types of ductwork specified in this Section include, but are not necessarily limited to the following:
 - 1. Air conditioning supply and return air systems
 - 2. Outdoor air supply systems
 - 3. Mechanical exhaust systems
 - 4. Air relief systems
 - 5. Kitchen exhaust systems (tenant)
 - 6. Combustion flues
- C. **[VAV Supply Air Ductwork Upstream of Terminal Units:]** Ductwork shall be sheet metal designed for velocities up to 2500 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork.
- D. **[Supply Air Ductwork Downstream of Terminal Units:]** Ductwork shall be sheet metal ductwork designed for velocities up to 1500 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork.
- E. **[Outside Air Ductwork:]** Ductwork shall be sheet metal ductwork designed for velocities up to 2500 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork.
- F. **[Garage Supply and exhaust Ductwork:]** Ductwork shall be sheet metal ductwork designed for velocities up to 2500 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork.
- G. **[Stairwell Pressurization Ductwork:]** Ductwork shall be sheet metal ductwork designed for velocities up to 2500 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork.

- H. **[Restroom and General Exhaust Ductwork:]** Ductwork shall be sheet metal ductwork designed for velocities up to 1500 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork.
- I. **[Smoke Exhaust and Relief Air Ductwork:]** Ductwork shall be sheet metal ductwork designed for velocities up to 2500 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork.
- J. **Flexible Ductwork:** Ductwork connections to HVAC terminal units and air devices shall be made with flexible ductwork connection where shown on the Drawings. Additional connections may be made using flexible ductwork at the Contractors opinion, where approved in writing, in advance, by the Engineer. Flexible duct work to air devices shall in no instance exceed 6'-0" in length. Flexible duct from the main air trunk to a VAV terminal unit shall not exceed 2'-0" in length and shall be rated for high pressure.
- K. **Ductwrap Insulation:** Refer to section 15250, "System Insulation", for external ductwork insulation.
- L. **Grease Exhaust Ductwork:** Black steel utilized for grease exhaust ductwork shall be minimum 0.054" thick (16 gauge MSG) black carbon steel. Access panels shall be secured to the duct in a similar manner to the prescribed in NFPA 96 for the hood-to-duct connection.
- M. **Dishwasher Ductwork:** Stainless steel utilized for dishwasher exhaust ductwork shall be a minimum 18 gauge stainless steel with #4 finish. All seams shall be welded and polished. Ductwork shall slope toward equipment at a minimum of 1/8" per foot. Ductwork above ceiling shall be insulated

1.03 Quality Assurance:

- A. Design and Installation Standards:
 - 1. SMACNA Standards (latest editions):
 - a. HVAC Duct Construction Standards – Metal and Flexible
 - b. HVAC Air Duct Leakage Test Manual
 - c. Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
 - d. Seismic Restraint Manual: Guidelines for Mechanical Systems
 - 2. ASHRAE Guide and Data Book, "Handbook of Fundamentals" (latest edition)
 - 3. NFPA 90-A, Standard for the Installation of Air Conditioning and Ventilating Systems, 1980 edition.
- B. Fire and Smoke Rating Test Standards: ASTM E84, NFPA 255 and UL 723.

1.04 Delivery, Storage and Handling:

- A. Protect shop fabricated and factory fabricated ductwork, accessories and purchased products from damage during shipment, storage, and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings by sealing each end with plastic.

- B. Where possible, store ductwork inside and protect from the weather. Where necessary to store outside, store above grade and enclosed with waterproof wrapping.

1.05 Submittals:

- A. Shop Drawings: Submit dimensioned layouts of ductwork showing both the accurately scaled ductwork and its relation to space enclosure. Show modifications of indicated requirements, made to conform to local shop practice and how those modifications ensure that the free area, materials, and weights are not reduced.

Part 2 Products:

2.01 Ductwork Materials:

- A. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discolorations, and other imperfections, including those which would impair painting.
- B. Gauges, Rectangular Ductwork: Fabricate galvanized steel ductwork from the minimum gauges for sizes up to the corresponding maximum long-side dimensions as indicated in SMACNA Duct Construction Standards.
- C. Gauges, Round Ductwork: Fabricate lock-form quality galvanized steel ductwork from the minimum gauges for diameters up to the corresponding maximum dimensions as indicated in SMACNA Duct Construction Standards.
- D. Fiberglass Duct board: Fiberglass duct board is NOT an acceptable means of air transport.

2.02 Miscellaneous Ductwork Materials:

- A. General: Provide miscellaneous materials and products of the types and sizes indicated and where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.
- B. Duct Sealant: Provide non-hardening, non-migrating mastic or liquid elastic sealant (type applicable for the fabrication/installation detail) as compounded and recommended by the manufacturer specifically for sealing joints and seams in ductwork.
- C. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim, and angles for support of ductwork.
- D. Duct Liner Adhesive: Comply with ASC-A-7001 by The Adhesive and Sealant Council, Inc. (see SMACNA standards).
- E. Duct Liner Fasteners: Comply with SMACNA.
- F. Flexible Ductwork: Insulated flexible ductwork shall be Wiremold Type VTCK. Approved equal flexible ductwork by Certainteed Corporation, Clevaflex, Flexaust Company, Flexmaster, Genflex, Owens-Corning Fiberglass, Norflex, or Thermaflex will be acceptable. Provide either 45 degree angle taps with manual volume dampers or "spin-in" taps with manual volume dampers at main duct tap as shown on Drawings.

2.03 Direction and Volume Control and Fire Dampers:

- A. General: Provide all direction, volume control and fire dampers shown or noted on Drawings. All damper control devices shall be installed so as to be fully concealed in finished rooms and spaces.
- B. Control Dampers:
1. Splitter Dampers: Splitter dampers shall be not less than 16 gauge. Splitter dampers shall be 1-1/2 times the width of narrowest duct leaving split, except not less than 12" long and shall have not more than 1/4" less height than duct in which it is installed. Splitter dampers having area less than 2.25 square feet shall be adjusted by means of a locking quadrant mounted on end of shaft. Splitter dampers having larger area shall be adjusted by means of one or more push rods in accordance with Figure 2-5, SMACNA "Low Velocity Duct Construction Standards".
 2. Pressure Taps: Where rectangular take-offs of branches from main ducts are used with 45 degree entry, provide manual volume regulators with lockable operators.
 3. Round Taps: Where taps to main ducts or their branches are made, provide 45 degree angle taps or 90 degree spin-in taps with manual volume dampers.
 4. Multi-leaf Dampers: Where multi-leaf dampers are required, provide opposed blade-type in accordance with SMACNA "Low Velocity Duct Construction Standards".
 5. Manual Volume Dampers: Single blade butterfly dampers are acceptable up to 12" round or 12" x 12" square. Dampers larger than these dimensions shall be multi-blade type. Single blade dampers shall be constructed of 16 gauge or heavier galvanized sheetmetal. No multi-blade damper blade shall exceed 8" in width. All multiple blade dampers shall be constructed of 16 gauge galvanized steel or heavier. The damper frame shall be 16 gauge or heavier. The damper action shall be opposed-blade type. Each blade shall pivot on a 1/2" cadmium plated, cold-rolled steel axle which pivots within self-lubricating, oilite bronze bearings. The operating rod for all dampers shall be extended outside the damper frame for attachment of an operator. Each operator shall have a position indicator and locking quadrant.
- C. Smoke Dampers: Smoke dampers shall be UL-listed as Class 1 low-leakage smoke dampers.
- D. Fire Dampers: Provide fire dampers at duct penetrations of floors, smoke partitions, fire walls, and where required by the applicable building codes or authority having jurisdiction. Fire dampers shall comply with state and local codes, be inspected and approved by an approved inspection agency and be labeled at the factory in accordance with Uniform Building Code Standard 43, Section 43.714. Dampers installed within ducts shall be Type B or Type C with the blades out of the airstream. Areas indicated shall be net, clear, open areas.
1. Provide one-hour rated dampers where penetrations are in required one-hour fire rated assemblies.
 2. Provide 1-1/2 hour rated dampers where penetrations are in required 2-hour fire rated assemblies.
 3. Provide 3 hour rated dampers where penetrations are in required 4-hour fire rated assemblies; 4-hour occupancy separating walls are accepted.

2.04 Duct Access Doors:

- A. General: Provide hinged duct access doors, gasketed and with insulation where ductwork is indicated to be insulated. Provide construction per SMACNA Standards. Access doors shall be at least 15" x 15".
- B. Inspection Plates: Provide inspection plates as required. Provide a minimum opening of 4" x 4" with a 6" x 6" cover plate. The cover plate shall be one gauge heavier than the ductwork, gasketed and secured with a minimum of eight sheetmetal screws.

2.05 Miscellaneous Ductwork Materials:

- A. General: Provide miscellaneous materials for ductwork accessories, including hinges, refrigerator latches, sash locks, bolts and wing nuts, gaskets and pitot tubes as recommended by the ductwork accessories manufacturer for the application indicated.

2.06 Turning Vanes:

- A. Construct turning vanes in accordance with SMACNA Standards (current edition).

Part 3 Execution

3.01 General Requirements:

- A. Standards: Round and rectangular sheet metal ductwork shall be constructed in accordance with SMACNA "HVAC Duct Constructions Standards", latest Edition, ASHRAE Guide and Data Book, "Handbook of Fundamentals", latest edition, specifically Chapter 25 and NFPA Standard 90-A, "Standard for the Installation of Air Conditioning and Ventilating Systems".
- B. All ductwork required for the heating, ventilating and air conditioning systems shall be constructed and erected in a first class workmanlike manner. This work shall be guaranteed for a period of one year from and after the date of acceptance of the job against noise, chatter, whistling, vibration, and free from pulsation under all conditions of operation.
- C. The interior surface of all ductwork shall be smooth with no parts projecting into the air stream unless specified to do so. All seams and joints shall be external. The inside of all ductwork shall be thoroughly cleaned and all fans operated to remove any debris prior to connection of air devices.
- D. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for any length of time.
- E. Where ducts, exposed to view (including equipment rooms), pass through walls, floors or ceilings, furnish and install sheet metal collars around the duct.
- F. Sheet metal plenums shall be constructed and reinforced in accordance with SMACNA standards. Where plenums are connected to louvers, the plenum bottom shall be sloped to drain to the louver.

- G. Ductwork which is exposed to weather shall have soldered joints and seams and shall be painted with a suitable epoxy coating. In lieu of solder joints, the use of Ductmate or TDC manufactured flanges are acceptable.

3.02 Coordination:

- A. Prior to submitting ductwork shop drawings, the Division 15 Contractor shall fully coordinate the routing and height of all ductwork with all other trades and with ceiling heights, lighting fixtures and building construction.

3.03 General Ductwork Fabrication:

A. Duct Gauge and Reinforcing:

1. Rectangular Ductwork: Minimum metal gauges and reinforcement shall be in accordance with SMACNA HVAC Duct Construction Standards (SDCS)
2. Round Ductwork: Minimum metal gauges for longitudinal and spiral seam round ductwork shall be in accordance with SDCS. Longitudinal seam ductwork larger than 12" diameter shall not be permitted unless welded seams are used.
3. Cross-breaking: Cross-break or transverse bead all flat surfaces which are more than 12" wide. Transverse beading shall be on 12" centers and shall be a minimum of 1/8" deep at the center of the bead and 3/8" wide at the base of the bead.
4. Minimum Gauges: The metal gauges listed in the SDCS for round and rectangular ductwork are the minimum recommended. It shall be the Contractor's responsibility to select a metal gauge heavy enough to withstand the physical abuse of installation.

B. Duct Joints and Seams:

1. General: Make all joints airtight. The distance between transverse joints on any size duct shall not exceed 5'.
2. Rectangular Ductwork: Transverse joints and longitudinal seams in ductwork shall be constructed in accordance with SDCS Drive slips may be used on rectangular ductwork on short sides only, up to 18" maximum. Gauge of drive slips shall be at least as heavy as ductwork on which they are installed. Bend drive slips over at least 3/4" at corners. Corner closures shall be in accordance with SDCS Fig. 1-13 through 1-18. All longitudinal seams shall be "Pittsburgh Lock" or button punch snap lock at corner seams and grooved seam or seam welded in sides between corners, in accordance with SDCS. At the Contractor's option, transverse joints may be transverse duct flange joints or Ductmate EP12/11 prefabricated galvanized Ductmate sections. The proposed gasket material, flange, corner piece and Ductmate details shall be submitted for approval.
3. Round Ductwork: Transverse joints for round ductwork shall be beaded sleeve type constructed in accordance with SDCS, properly secured and sealed. Draw bands shall not be used on round ductwork. Longitudinal and spiral seams shall be constructed in accordance with SDCS 1.
4. Ductwork Sealing: Seal all longitudinal and transverse ductwork joints as outlined per SMACNA. All medium pressure ductwork (3" WC static pressure class at 4000 FPM velocity) shall be provided with Class A seals. All low pressure ductwork (1" WC static pressure class at 2500 FPM) shall be provided with Class C seals.

C. Connections and Take-offs:

1. Rectangular Ductwork: Parallel flow branches shall be constructed using radius elbow take-offs in accordance with SDCS. Branch duct connections shall be 45 degree entry expanded taps constructed in accordance with SDCS. Duct-mounted coil connections shall be constructed in accordance with SDCS.
2. Round Ductwork: Connections and takeoffs shall be made using 90 degree conical taps, 45 degree lateral taps or wye fittings constructed in accordance with SDCS Fig. 3-4 and 3-5. Use of 90 degree tees shall not be allowed.
3. Spin-in Fittings: Spin-in fittings may be used for duct taps to air supply and exhaust devices and shall include quadrant dampers even though a volume damper may be specified for the air device. Spin-in fittings shall be sealed at the duct tap with a gasket and compression fit or sealed with duct sealant. The location of spin-in fittings in the ducts shall be determined after terminal units are hung and the location of the light fixtures is known so as to minimize flexible duct lengths and sharp bends. Spin-ins shall be installed with their damper axis parallel to airflow. Tape on spin in fittings will not be allowed.
4. Flexible Joints In Ductwork: Provide flexible connections where ductwork connects to air-handling units, fans, and similar powered equipment items and where required for expansion and contraction of the ductwork or the building structure. A minimum of one inch (1") slack shall be provided in all flexible connection to insure vibration isolation. Flexible joints are not required where equipment is connected with flexible duct. Flexible connections shall be rigidly connected to metal work on each side and shall be airtight. Bond flanges of flexible duct connectors to ducts and housings to provide airtight connections. Seal seams and penetrations to prevent air leakage.

D. Elbows and Tees:

1. Rectangular Ductwork: Provide radius or square elbows in ductwork, where shown on the Drawings. Where radius elbows are shown, radius elbows must be provided. Where square elbows are shown, square or radius elbows may be provided, at the Contractor's option. Elbows shall be constructed in accordance with SDCS. Turning vanes are required in all square elbows of 46 degrees or greater angle. Turning vanes are not required in radius elbows. Turning vanes shall be single vane type without a trailing edge and shall be constructed and installed in accordance with SDCS. All elbows in medium pressure ductwork shall be radiused with no turning vanes.
2. Round Ductwork: Provide radius elbows of the stamped or segmented type constructed in accordance with SDCS. Segmented elbows shall have a minimum of three segments for 45 degree elbows and five segments for 90 degree elbows.

E. Offsets and Transitions: Where duct width increases, maximum angle of slope shall be 20 degrees (one inch (1") in 2.7"). Where duct width decreases, maximum angle of slope shall be 30 degrees (one inch (1") in 1.7"). Offsets and transitions shall be constructed in accordance with SDCS.

F. Air Device Connections: Make connections to air devices and fabricate air device plenums as detailed on the Drawings and in accordance with SDCS

3.04 Duct Liner:

- A. General: The liner shall be applied to the inside of the duct with heavy density side to the air stream and shall be secured in the duct with adhesive, completely coating the clean sheet metal. All joints in the insulation shall be "battered" and firmly butted tightly to the adjoining liner using fireproof adhesive. Where a cut is made for duct taps, etc., the raw edge shall be accurately and evenly cut and shall be thoroughly coated with fireproof adhesive. On ducts over 24" in width or depth, the liner shall be further secured with mechanical fasteners. The fasteners shall be A.J. Gerrard Company pronged straps, or approved equal, secured to the ducts by fireproof adhesive. The clips shall be 18" maximum spacing and shall be pointed up with fireproof adhesive. Liner shall be accurately cut and ends thoroughly coated with fireproof adhesive so that when the duct section is installed, the liner shall make a firmly butted and tightly sealed joint. Where ducts are lined exterior insulation will not be needed unless otherwise noted, except that the two insulations shall lap not less than 24". Duct liner for velocities over 2500 fpm shall be as specified except a perforated metal liner shall be used over duct liner for securing, in lieu of fasteners. Duct liner installation and fasteners shall comply with SDCS. Refer to specification Section 15250 for duct liner product specification.

3.05 Ductwork and Accessories Installation:

- A. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve airtight and noiseless systems, capable of performing each indicated service. Install each run with a minimum of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers, and anchors of the type which will hold ducts true-to-shape and prevent buckling.
- B. Inserts: Install concrete inserts for support of ductwork in coordination with formwork, as required to avoid delays in the work.
- C. Completion: Complete fabrication of work at the project as necessary to match shop-fabricated work and accommodate installation requirements.
- D. Run Location: Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, grams, details, and notations or, if not otherwise indicated, run ductwork in the shortest route which does not obstruct usable space or block access for servicing the building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of the building. Limit clearance to 0.5" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork to assure 1.0" clearance of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate the layout with suspended ceiling and lighting layouts and similar finished work.
- E. Coordination: Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of the ductwork system.
- F. Hangers and Supports:
1. General: All ductwork supports shall be per Section IV of the SMACNA "HVAC Duct Construction Standards (latest edition) with all supports directly anchored to the building structure. Supports shall be on maximum 8'-0" centers with additional supports as required to prevent sagging.

2. Hangers: Hangers shall be strap or rod sized in accordance with SDCS. Strap hanger attachment to rectangular duct shall consist of a turning strap under the duct a minimum of one inch (1") and securing the strap with one screw into the bottom of the duct and one screw to the side of the duct. Rectangular duct supported on trapeze hangers shall be attached to the trapeze. Round duct attachments shall be constructed in accordance with SDCS.
3. Horizontal Ducts: Ducts larger than 50" in their greatest dimension shall be supported by means of hanger rods bolted to angle iron or half round trapeze hangers.
4. Vertical Ducts: Ducts shall be supported where they pass through the floor lines with 1-1/2" x 1-1/2" x 1/4" angles for ducts up to 60". Above 60", the angles must be increased in strength and sized on an individual basis considering space requirements.

G. Flexible Ductwork:

1. General: Flexible ductwork shall be provided as shown on Drawings. Flexible ducts shall be installed in a fully extended condition free of sags and kinks, using only the minimum length required to make the connection, subject to the maximum lengths herein below. Bends in any length of flexible duct shall not exceed 45 degrees for HVAC terminal unit connections or 135 degrees for air device connections and shall not exceed that recommended by the flexible ductwork manufacturer. Unless otherwise shown on the Drawings, the length of any one run of flexible ductwork shall not exceed 2 feet to terminal units or 6 feet to air distribution devices.
2. Supports: Where flexible duct extension exceeds 48", horizontally, a support shall be provided. Duct shall be suspended on 48" centers with a minimum one inch (1") wide flat banding material. Refer to SDCS for additional requirements.
3. Terminal Unit Flexible Duct Connections: The terminal ends of the duct core shall be secured by stainless steel worm gear type clamps. The fittings on terminal units and on sheet metal duct shall be coated with sealant, then the flexible duct core slipped over duct and the clamp tightened, and the connections shall be sealed with duct sealant. Insulation of flexible duct shall be slipped over connection to point where insulation abuts terminal unit or insulation on duct and attached with self-locking nylon straps. The insulation connections shall then be sealed using foil duct tape to provide vapor barrier. Refer to SDCS for additional requirements.
4. Air Device Flexible Duct Connections: All joints and connections shall be made by turning back the insulation and securing the inner liner with self-locking nylon straps and sealing with two wraps of duct tape. The insulation shall then be placed over the joint, attached with a self-locking nylon strap and sealed on the exterior with an approved foil duct tape. Refer to SDCS for additional requirements.

H. Duct Mounted Devices:

1. Install duct mounted sensors and control devices furnished under Section 15950, "Building Automation System". Provide access doors at each duct mounted control device. Coordinate location of devices and installation requirements with the Section 15950 Contractor.
2. Install duct type smoke detectors furnished under Division 16. Provide access doors at each sampling tube assembly. Coordinate location of detectors and installation requirements with Division 16.

3. Provide duct test ports in ductwork as required to properly balance all air systems. Test ports shall be located per ANSI/ASHRAE Standard III to allow accurate pitot-tube traverse measurements in ductwork.
4. Access Doors: Install access doors so that the doors open against the system air pressure wherever feasible and that their latches are operable from either side, except where the duct is too small to be entered. Provide access to each fire damper link to permit resetting. Comply with the applicable building codes or authority having jurisdiction and NFPA 96.
5. Inspection Plates: Install plates at each primary zone damper and where otherwise required for inspection of operable mechanisms within the duct systems.
6. Multi-leaf Dampers: Install multi-leaf volume dampers in each zone duct of multi-zone units and as otherwise required for balancing.
7. Splitter Dampers: Install splitter dampers at all divisions of ductwork for proper air pattern control.
8. Turning Vanes: Install turning vanes for all rectangular mitered elbows. Install turning vanes in accordance with SMACNA Standards.
 - a. Turning vanes for Ducts with air velocity less than 2000 FPM: Use single wall type vanes for ducts having width equal to or less than 12 inches.
 - b. Use double wall type vanes for (2" radius, 2–1/8" spacing) for ducts having widths greater than 12 inches.
 - c. If duct sizes change in a mitered elbow, use single wall type vanes with a trailing edge extension.
 - d. Turning vanes shall not be used on any ductwork with velocity greater than 2000 fpm.

3.06 Cleaning and Protection:

- A. General: Clean ductwork internally, section-by-section of dust and debris as it is installed. Clean external surfaces of foreign substances which might cause corrosive deterioration of the metal or, where ductwork is to be painted, might interfere with painting or cause paint damage.
- B. Repairs: Strip protective paper from stainless ductwork surfaces and repair finish or replace ductwork portion wherever it has been damaged.
- C. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at the time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent the entrance of dust and debris until such time that connections are to be completed.

END OF SECTION 15891

Section 15931 – VAV and Fan Powered Air Terminal Units

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Provide variable air volume (VAV) and fan powered air terminal units with manufacturer or BAS contractor supplied DDC controller (If Applicable) for factory mounting.

1.03 Quality Assurance:

- A. Provide VAV and fan powered system terminal units complying with the following standards:
 - 1. ANSI/ASHRAE 130-1996 (RA 2006) Method of Testing for Rating Ducted Air Terminal Units
 - 2. Sound ratings shall not exceed NC 35 without credit for duct or room attenuation. Unit sound performance shall be ARI certified and shall be measured in accordance with ASHRAE Standard 36B-63
 - 3. Unit leakage ratings shall be in accordance with current ADC Test Code 1062R4.
 - 4. Sound ratings shall be in accordance with ARI Standard 880-98. Air Terminals

1.04 Submittals:

- A. Shop drawings submittals shall include, but are not limited to, the following:
 - 1. Unit cutsheets clearly showing all features, accessories, dimensions, weights, and capacities.
 - 2. Written instructions for equipment to installation.
 - 3. Wiring and piping diagrams and connection locations.
 - 4. Performance certifications and test results.
 - 5. Warranty information.
 - 6. Additional information as required in Section 15010.

Part 2 Products

2.01 Materials:

- A. General: Provide air terminal units of standard materials and components designed and constructed as recommended by the manufacturer and as required for a complete installation in compliance with these Specifications. Units with electrical equipment shall be constructed

in accordance with NEMA and NEC and shall include disconnects or fused disconnects where specified required by the NEC.

2.02 Manufacturers: Provide units of one of the following acceptable manufacturers:

- A. Anemostat
- B. Carrier
- C. Envirotec
- D. Metalaire
- E. Nailor
- F. Price
- G. Titus
- H. Trane

2.03 Fan Powered Terminal Units:

- A. General: Provide [intermittent] [constant] volume series or parallel (Building standard accepted only), pressure independent fan-powered terminal units consisting of a sheet metal housing with a control damper, damper operator, fan assembly, electric heating coil (where scheduled), and flow controls. Unit type and configuration shall be as determined by project specific application. Fan powered terminal units shall be compatible with the temperature controls as specified in Section 15950, "Direct Digital Control System". (If Applicable)
- B. Housing: Shall be constructed of 22 gauge minimum galvanized sheet metal with a rigid frame with mechanical seals and gaskets to minimize housing leakage to less than 1% of rated capacity at rated inlet static pressure. Housing shall be lined with 1/2 inch, dual density fiberglass coated with high density sealant to prevent air erosion. Insulation shall meet the requirements of NFPA 90A and UL 181. Gasketed access doors shall be provided on the bottom of each unit. Housing shall be provided with a round or oval inlet for use with flexible duct (3000 fpm maximum velocity) and a rectangular outlet for slip and drive connection to sheet metal ductwork (1800 fpm maximum velocity). The maximum static pressure drop through the unit at maximum design airflow shall be 0.45" W.C.
- C. Control Damper: Shall be of a low leakage, opposed blade or single blade design with self-lubricated bearings. Dampers shall be suitable for use with electric operators.
- D. Leakage: Overall leakage for the control damper and pressurized portions of the housing shall be less than 3% of nominal cfm at 3" inlet SP and scheduled outlet SP, as rated by ADC Test Code 1062 R4.
- E. Damper Operators: Shall be a electric type normally closed damper operator rigidly attached to the terminal unit and connected to the damper with an adjustable linkage. Operators shall be sized to properly operate the unit dampers. Dampers shall be factory-mounted and wired including all controls required for operation, except control wiring connections. Operator springs shall be selected to coordinate with the control sequence shown on the Drawings and

specified. All exposed operator/linkage components shall be protected with removable metal covers.

- F. Fans: Provide fans balanced statically and dynamically, of the indicated capacity, designed and assembled to be easily removed for servicing. Fan and motor shall be internally isolated from housing using either torsion-flex suspension or rubber isolators. Fans shall be of metal construction. Provide centrifugal fan wheels designed for discharge static pressures indicated on the Drawings. System shall be non-overload. Provide vibration isolation as required. Fans shall be oriented for air flow in **[parallel] [series]** orientation for **[intermittent] [constant]** volume operation (building standard accepted only).
- G. Motors: Provide motors of the indicated or required capacity, installed for easy removal, with automatic reset thermal overload protection of the three tap, three winding, permanent split-capacitor type suitable for use with a fan speed controller. Provide sleeve type motor bearings, graphite bronze or equivalent. Motor voltage shall be as scheduled on the Drawings. Fan-motor combination shall be a manufactured product with sufficient actual installed experience to verify a minimum of a 15 year average service life. Average service life shall be certified by an authorized officer of the company. Motors shall be of a type suitable for use in the specified terminal unit. Motor shall turn fan in the proper rotation, irrespective of condition at fan start up. Provide full range speed controls for final balancing. Speed controls shall have minimum voltage stops factory-set to protect motors from low speed burnout. Motor shall have unit mounted three speed controller. Fans shall run in low or medium speed. High speed fan operation shall not be allowed.
- H. Terminal units shall include a filter rack on the plenum inlet suitable for filter removal without the use of tools. Filters shall be sized for a maximum of 600 FPM air velocity. Provide 1" thick disposable fiberglass filters
- I. Electrical Connections: Provide fan powered terminal units designed for a single electrical power feed and complying with all applicable NEC and UL requirements and all other applicable Codes and Standards. For terminal units without electric heating coils, provide unit-mounted fused disconnect switches with factory wiring from the load side of the disconnect switch to the fan motor. The only field wiring shall be to the line side of the disconnect switch. For terminal units with electric heating coils, provide individual unit-mounted fused disconnect switches, one for the fan motor and one for the heating coil. Disconnect switches shall be factory-wired on the load side to the load served and shall be tapped together on the load side such that only a single incoming electrical feeder connection is required. Provide control transformer as required. Refer to Division 16, "Electrical", for fuse and disconnect switch specifications. Fuses shall be sized for a nominal 125% of full load amperes of the load served.
- J. Heating Coils:
1. Integral hot water reheat coils shall be provided where scheduled or shown on the Drawings in a minimum 22 gauge galvanized metal casing with slip and drive connection for attachment to discharge ductwork. Coil shall be constructed of seamless copper tubes with mechanically bonded aluminum fins and sweat-type water connections. Aluminum fins shall have full fin collars to assure accurate fin spacing and maximum surface contact. Coils shall be leak tested to a minimum 300 psi under water. Coil capacities shall meet scheduled requirements on the Mechanical Contract Drawings and shall be based on tests run in accordance with ARI Standard 410. Number of coil rows and circuits shall be no less than as scheduled.

2. Electric heating coils shall be provided on fan powered terminal units where scheduled or shown on the Drawings. The 480 volt heaters shall be delta wired. Units with heaters shall be UL-listed for zero clearance, shall bear the UL-listing mark and label and shall meet all National Electrical Code (NEC) requirements. Heater frames, enclosures, and terminal boxes shall be constructed of galvanized steel. Heating elements shall be Type A 80-20 nickel/ chromium wire and shall not glow when operating per design. Heaters shall be provided with factory-installed and wired branch circuit fusing as required by the NEC and UL.
 - a. Each heater shall be complete with silent magnetic contactors for each stage, a primary thermal cutoff to de-energize the heater in case of overheating, a differential air pressure switch and electronic controls for each heater contactor. All electric heaters over 10 KW shall be staged in increments not exceeding 10 KW .
 - b. Each heater shall be complete with SCR controls as required for non-staged, variable heating control, a primary thermal cutoff to de-energize the heater in case of overheating, and a differential air pressure switch.
- K. Furnish a factory assembled acoustical attenuator plenum on the terminal unit discharge only on all units as required to meet maximum NC35 radiated and discharge sound levels. Plenum shall be lined with 1" thick, minimum 1.5 lb/cu.ft. density thermal/acoustical insulation coated with high density sealant which complies with NFPA 90A and UL 181. Attenuator width, height, and construction are to match terminal unit
- L. Direct Digital Controller – Each unit shall have a factory installed DDC controller. Unit controller shall control all operating and safety functions for the terminal unit. The controller shall be an integral part of the terminal unit and shall incorporate LonMark open-protocol communications and shall have read/write points per the LonMark VAV Controller Functional Profile. Refer to specification Section 15950 "Building Automation Systems.

2.04 [Single Duct VAV Air Valve Terminal Units:] Not Acceptable

Part 3 Execution

3.01 Equipment Set-up, Configuration, Check-Out and Building Automation System Integration

- A. All controller setup/configuration required to meet the operating and control requirements of the specifications are to be performed at the factory. Any controller setup/configuration required for proper operation of the equipment that is not performed at the factory is to be performed in the field by the equipment supplier. This includes any field setup/configuration/wiring changes required to have the controller meet the specified sequence of operation and integration requirements. Need to discuss, there are several set up function in the field that are completed by the T&B contractor and etc.
- A. Equipment supplier to provide documentation listing all of the data points for his equipment, including data point name, data point type and description of the data point's function.
- B. Equipment supplier to provide on-site technical support for data integration/verification between the equipment manufacturer's open protocol controller and the Building Automation System. Equipment supplier's on-site technical support person to be factory trained and certified in the configuration, operation, checkout and troubleshooting of the equipment manufacturer's open-protocol controller.

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- C. Equipment supplier is responsible for any and all ancillary warranty work associated with the repair/replacement of its defective open protocol controllers. This includes, but is not limited to, repair/replacement of defective open protocol controllers, setup/configuration of repaired/replaced defective controllers, re-integration into the Building Automation System, etc.
- D. Equipment Supplier, Temperature Controls Contractor, and HVAC Contractor and VPTC Management Partners, LLC shall meet before equipment is installed to discuss all equipment installation.

3.02 Installation - General

- A. Install items in accordance with manufacturer's recommendations and instructions.
- B. Items which vibrate, whistle or rattle when system is in operation are considered defective. Replace any defective unit which cannot be tightened or adjusted to eliminate objectionable noises with new unit.
- C. Comply with all applicable code restrictions for installation of units, controls, and interconnecting tubing in ceiling.
- D. Support each fan powered air terminal unit from all four corners of the cabinet. Provide canvas flexible duct connection on the discharge of fan-powered terminal units.
- E. Position terminal units with electric reheat coils such that a minimum of 36" access clearance is available at electrical enclosure.
- F. Provide a minimum of two duct diameters of straight ductwork at each terminal unit inlet.
- G. Any New FTU/VAV must be installed outside of any executive office or conference room.
- H. Any existing FTU/VAV should be removed outside of any executive or conference room provided it physically can be due to change of existing space allows in the design.
- I. Perimeter Boiler Heat or Electrical Heat to stay intact and re-routed as needed in the base bid if any wall or obstruction occurs that causes them to be moved.
- J. Include in base bid any and all missing perimeter heat caps and repair or replace any damaged covers.
- K. Confirm with furniture plan that any existing or new FTU or VAV is fully serviceable with the use of a ladder. Equipment cannot be located above cubes, desks, solid ceilings where they cannot be accessed for service and require special equipment to access.

3.03 Additional Equipment:

- A. Install temporary filters during construction and prior to unit startup. Replace temporary filters with permanent filters just prior to balancing of system. Provide owner with one complete set of clean, spare filters at completion of project.

END OF SECTION 15931

Section 15940 – Air Outlets and Inlets

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1 and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included: Provide air outlets and inlets as required for the finished or non-tenant areas of the project including the following:
 - 1. Panel diffusers
 - 2. Grilles and registers
 - 3. Linear bar grilles
 - 4. Linear slot diffusers with boots

1.03 Quality Assurance:

- A. ASHRAE Compliance: Provide and install air outlets and inlets in compliance with the following ASHRAE Standards:
 - 1. ASHRAE 55-2004, Thermal Environmental Conditions for Human Occupancy
 - 2. ASHRAE 62.1-2004, Ventilation for Acceptable Indoor
 - 3. ASHRAE 70-2006, Method of Testing Performance of Air Outlets and Air Inlets.
 - 4. ASHRAE 113-2005: Method of Testing for Room Air Diffusion
- B. ADC Compliance: Test and rate registers, grilles, and diffusers in accordance with ADC Equipment Test Code 1062, provide Certified Ratings Seal on each unit.
- C. ARI Compliance: Test and rate registers, grilles, and diffusers in accordance with ARI Standard 650.
- D. NFPA Compliance: Comply with NFPA 90, as applicable to air diffuser construction and installation.
- E. AMCA Standard 210: Test Code for Air Moving Devices.
- F. Air Distribution Equipment: Maximum space temperature variation shall not exceed 2°F throughout the conditioned area from 2' above the floor to 7' above the floor. The air outlets shall be selected by the designer to suit the volume, throw, and noise level criteria described in these Specifications, and maintain maximum terminal velocities of 50 fpm at 2'-0" above finished floor, unless otherwise indicated.

Part 2 Products

2.01 Air Outlets and Inlets:

- A. General: Provide air outlets and inlets of the size, shape, and type, constructed of materials and components, and with finishes as required. Apply corrosion resistant treatment to surfaces prior to applying prime coat.
- B. Ceiling Diffusers:
1. In acoustical tile ceilings, provide panel or linear slot diffusers finished in white, baked enamel.
 - a. Panel diffusers shall be 22 gauge stamped steel construction and of a three-cone or flush panel design as required by the project.
 - b. Where applicable, provide adapters with panel diffusers to permit connection to round supply duct.
 - c. Linear slot diffusers shall have a minimum of two slots for adjustable, bi-directional throw.
 2. Provide reinforced, 24 gauge inlet plenum boot for linear slot diffusers to permit connection to round supply duct. Coordinate the attachment, support, and similar features of the supply plenum with the ceiling Subcontractor. The plenum shall be painted flat black on interior surfaces and the exposed surfaces as viewed from below the ceiling system shall be painted flat black.
 - a. Provide integral center T-bar for linear slot diffusers of 4' length.
 3. In finished gypsum ceilings including exterior lobbies, conference rooms and formal areas, provide continuous slot diffuser for appearance. Provide sheetmetal blank-off panel behind unused portions of diffuser. Coordinate location with the project Architect.
- C. Registers and Grilles:
1. Supply Air Register: Provide supply air registers of the double deflection type. Provide registers that contain a key-operated opposed blade damper operable from the face side.
 2. Exhaust and Return Air Registers: Provide registers of the single deflection type. Provide registers that contain a key-operated opposed blade damper operable from the face side.
 3. Return and Transfer Air Grilles: Provide "eggcrate" style grilles consisting of a ½" X ½" aluminum core surrounded by a perimeter aluminum frame. Finish shall be white, baked enamel.
- D. Manufacturers: Provide air outlet and inlet devices manufactured by the following:

1. Anemostat
2. Carnes
3. Krueger
4. Metal-Aire
5. Nailor
6. Price Industries
7. Titus
8. Tuttle & Bailey

Part 3 Execution

3.01 Installation:

- A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and recognized industry practices to ensure that products serve intended functions.
- B. Coordination: Coordinate with other trades, including ductwork, and ductwork accessories, as necessary to interface air outlets and inlets properly with other work.
- C. Secure all devices snug to ceiling. Support registers and grilles centered within acoustical ceiling tile from T-bars (not from pads), using horizontal channels secured to duct and T-bars.
- D. Install plaster type frames and wall mounted devices tight to walls.
- E. Diffuser, register, and grille locations shall be in accordance with
- F. reflected ceiling plan.
- G. All duct connections to supply, return, exhaust and relief outlets shall be banded and taped.

3.02 Field Quality Control:

- A. Test: Test installed devices to demonstrate satisfactory compliance with specified and indicated requirements.

END OF SETION 15940

Section 15950 – Building Automation System

PART 1 – GENERAL

1.1 DESCRIPTION

Provide a Building Automation System incorporating LonMark technology at the controller level and Niagara Framework AX version technology at the network device level and as network management tool. The BAS shall consist of Direct Digital Control controllers, Building controllers, Graphical User Interface through standard Web browsers, sensors, relays, valves, actuators, and other equipment as may be necessary to provide for a complete and operational control system for the HVAC and other building related systems as described within these specifications.

- A. The system installed shall seamlessly connect devices other than HVAC throughout the building regardless of subsystem type, i.e. HVAC, lighting and security devices should easily coexist on the same network channel without the need for gateways.
- B. It is **VPTC Management Partners, LLC's** expressed goal to implement an open Building Automation System that will allow products from various manufacturers to be integrated into an open unified system in order to provide flexibility for expansion, maintenance, and service of the system.
- C: It is also the intent of this specification that the TCC will provide to VPTC Management Partners, LLC all PC, Niagara AX platform and station system administration passwords with full rights and capabilities for access into all installed systems. In addition, any manufacturer's custom jar files must also be provided to be installed into VPTC Management Partners, LLC's Niagara AX Web Supervisor.

1.2 RELATED SECTIONS

- A. The General Conditions of this Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as apart of the contract documents.
- B. This section specifies equipment or systems, which will be commissioned as part of the construction process. The contractor will be required to provide documentation and testing of these systems, as well as training of the owner's operation and maintenance personnel. Final Acceptance is dependent on successful completion of all commissioning procedures, documentation, and issue closure.

1.3 DEFINITIONS & ABBREVIATIONS

- A. Abbreviations
 - 1. AI Analog Input
 - 2. AO Analog Output
 - 3. ASC Application Specific Controller
 - 4. ATC Automatic Temperature Controls
 - 5. BAS Building Automation System
 - 6. BI Binary Input (DI)
 - 7. BO Binary Output (DO)
 - 8. CHW Chilled Water
 - 9. CW Condenser Water

10.	DAT	Discharge Air Temperature
11.	DDC	Direct Digital Control
12.	DP	Differential Pressure
13.	DPS	Differential Pressure Switch
14.	H	Humidity
15.	HVAC	Heating Ventilation and Air-Conditioning
16.	MAT	Mixed Air Temperature
17.	NAT	Network Area Controller
18.	OAH	Outdoor Air Humidity
19.	OAT	Outdoor Air Temperature
20.	OWS	Operator Workstation
21.	P	Pressure
22.	PEC	Programmable Equipment Controller
23.	POT	Portable Operator Terminal
24.	RAH	Return Air Humidity
25.	RAT	Return Air Temperature
26.	T	Temperature

B. Non Technical Definitions:

1. **Building Automation System (BAS):** The entire system of microprocessor based hardware and software specifically designed to centrally manage building HVAC and related utilities. The BAS includes the tenant DDC subsystems, base building DDC subsystems, network controllers, data connections to other manufacturer's control systems for interoperability, operator workstations, central file server and TCP/IP Ethernet communications network.
2. **Base Building BAS (BB-BAS):** The part of the BAS that is provided and maintained by the Landlord.
3. **Owner Representative (OR):** Usually meaning the building's property manager, operations manager and/or chief engineer.
4. **System Integrator (SI):** The BAS contractor responsible for the integration and enterprise level.
5. **Temperature Control Contractor (TCC/TC):** The BAS contractor responsible for providing digital control systems within the Building that conform to these BAS Standard Requirements.
6. **Construction Documents (CD):** The plans and specifications developed for a development project.
7. **Temperature Control System (TCS):** The part of the BAS that directly monitors and controls equipment.
8. **Control Wiring:** Includes conduit, wire and wiring devices to install a complete and functional control system. This wiring includes motor control circuits, shut down interlock circuits, standalone thermostats, actuator end switches and like devices. Include all wiring from DDC controllers to all sensors, relays and actuators for the control point lists or as required to execute the sequence of operation. This wiring includes the necessary control power wiring to all control devices, actuators and digital controllers, including terminal unit controllers.
9. **Workmanship Defect:** Any item, which is not installed as specified in this and related documents shall be considered to be a defective in workmanship.

10. Where “as shown”, “as indicated”, “as detailed”, or phrases of similar meaning are used, reference is made to the Drawings accompanying the Specifications unless otherwise stated.
11. Where “as directed”, “as required”, “as permitted”, “as authorized”, “as accepted”, “as selected”, or phrases of similar meaning are used, the direction, requirement, permission, authorization, acceptance or selection by **VPTC Management Partners, LLC** is intended unless otherwise stated.
12. The term “provide” means “complete in place”, that is, furnished and installed and ready for operation and use.

C. Technical Definitions:

1. Algorithm: A software procedure for solving a recurrent mathematic or logical problem.
2. Analog: A continuously varying signal or value (temperature, current, velocity, etc.)
3. BacNet: The communication standards that comply with ASHREA/ANSI standard 135-1995 and all current revisions, and are certified as such by the governing organization.
4. Binary: A two-state system where “ON” condition is represented by a high signal level and an “OFF” condition is represented by a low signal level.
5. Control Process: The software required to perform a complete control loop from input signal to interlock logic, process calculation to final output signal control.
6. Deadband: A temperature range over which no heating or cooling energy is supplied, such as 72-78 °F, i.e. as opposed to single point changeover or overlap, or a range from setpoint over which no control action is taken.
7. Diagnostic Program: Machine-executable instructions used to detect and isolate system and component malfunctions.
8. Direct Digital Control System: The portion of the BAS which provides closed loop control of all HVAC equipment.
9. Distributed Control: A system whereby all control processing is decentralized and independent of a central computer.
10. Interoperability: The ability of control system components from different manufacturer’s to work together to provide coordinated control via real-time two-way data exchange through a common communications data exchange protocol. Interoperability shall extend to the operation workstation software which shall support user interaction with all control system components.
11. Link: A link is a graphical display element that allows the operator to “click” the item and automatically display the associated screen or service. Any screen may have links to or be linked from any other screen. Links shall be configured on each display screen to provide a logical user navigation system using a ladder tree hierarchy.

12. Link, Navigation: A navigation link is a link which allows the operator to move from display to display.
13. Link, Information: An information link is a link that activates support service or program to provide additional information for the operator. Example: a button that opens a file in Excel and prints a custom user report.
14. LON: Open communication protocol systems marketed and produced by Echelon that uses an Echelon chip and whose communication protocols and functional profiles conform the guidelines of the LonMark Interoperability Association, and are certified compliant by that organization. API communications are absolutely not allowed.
15. Modbus: Open communication protocol developed and marketed by MODICON Corporation. Utilizes RS-485 open protocol in either a master or master/slave configuration. Manufacturer users of this protocol shall provide a complete points register guide of all complete readable and writable points.
16. Network: A system of distribution control units that are linked together on a communication channel. A network allows sharing of point information between all control units. Additionally, a network provides central monitoring and control of the entire system from a distributed control unit location. First and Second tier networks shall provide "Peer-to-Peer" communications. Third tier networks that provide either "Peer-to-Peer", Master-Slave or Supervised Token Passing communications are absolutely not allowed.
17. Operator System (OS): Software which control the execution of computer programs and which provides scheduling, debugging, Input/Output controls, accounting, compilation, storage assignment, data management, and related services.
18. Operator Workstation (OWS): A personal computer used by an operator to view, command and program the operation of the BAS.
19. PID Control Loop: A mathematical calculation used to evaluate a control input and determine the control output value required to maintain the input value at setpoint. The PID (Proportional, Integral, Derivative) control loop shall have operator adjustable maximum rate of change, P, I and D gains and loop response time delay. PID control loops shall calculate based on actual conditions. Each output position update shall be made from the current output value, not a hard coded bias. PID control loops which use a non self tuning bias or are subject to integral windup will not be accepted.
20. Smart Device: A device containing a microprocessor, communication hardware and software providing two-way communication over media LON communication bus.

1.4 CODES AND STANDARDS

- A. All work, materials and equipment shall comply with rules and regulations of all codes and ordinances of the local, state and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications. As a minimum, the installation shall comply with the current editions of the following codes that were in effect 30 days prior to receipt of bids:
 1. National Electric Code (NEC)

2. International Building Code (IBC)
 3. International Mechanical Code (IMC)
- C. Provide electrical products which have been tested, listed and labeled by UL.
- D. Comply with NEMA standards pertaining to components and devices for electrical control systems.
- E. Comply with NFPA 90A “Standard for the installation of Air Conditioning and Ventilation Systems” where applicable to controls and control sequences.
- F. All BAS central equipment shall be UL916 listed.
- G. All electronic equipment shall conform to the requirements of FCC regulations Part 15, Section 15 governing radio frequency electromagnetic interference and be so labeled.

1.5 DESCRIPTION OF WORK

- A. General Requirements
1. Provide a complete and operational system to perform all sequences of operation stated within Part 4 (Sequence of Operation).
 2. The work under this Section shall include all materials and equipment, labor and services to perform all work required for the installation of the BAS as herein specified and as otherwise required to provide a complete and operation system according to standard industry practices.
 3. Note that the drawings and specifications are complementary to one another, meaning that what is called for one is to be considered called for both. Where conflicts exist between the specifications and/or drawings, the more stringent or inclusive requirement shall apply.
 4. Code requirements are considered a minimum standard. Where materials shown on the drawings or indicated in the specifications exceed code requirements, the plans and specifications shall govern.
 5. Minor BAS items, accessories, devices, or program features reasonably inferable as necessary, to the complete and proper installation and operation of any system, shall be provided by the Contractor installing the BAS for such system whether or not they are specifically called for by these specifications or drawings.
 6. If the Contractor installing the BAS has any question concerning the nature, extent or intent of the BAS work to be performed after examining all drawings and documents pertaining to this project, the Contractor installing this BAS work shall be responsible for obtaining clarification to those questions from **VPTC Management Partners, LLC** prior to submitting a project bid and/or technical proposal. Once a contract is awarded, claims of ignorance of the project requirements will not be considered.
 7. For retrofit projects or Tenant Finish Projects, perform field verification of site conditions and gather all necessary field data for all items to be provided under this contract prior to submitting a project bid and/or technical proposal. This shall include, but not be limited to: collection of manufacturer name plate data, duct and damper sizes, valve and pipe sizes, locations and accessibility of systems and equipment, and coordination data from other trades.

8. Where work specified under other sections of these specifications connects to the equipment or systems which are part of this section provide proper connection(s) to such equipment including trade coordination.
 9. All features of the BAS as specified herein shall be fully implemented and provided by a qualified, BAS Contractor as defined herein.
- B. The intent of this specification is to install a new BAS as noticed in this specification.
1. The BAS will employ a web interface based on a Tridium Niagara AX for Network Infrastructure (Jace Network Controllers, Tridium Web Server, Workplace Pro). No substitutions will be allowed.
 2. All controller-to-controller communication, controller-to-workstation communication and controller-to-Internet communication within the BAS will take place over communication networks that comply with LON. No substitutions will be allowed unless approved through VPTC Management Partners, LLC (14) days prior to the assigned bid due date.
 3. The BAS will be capable of connecting to **Duke's Realty's** Wide Area Network such that the system will be accessible through **VPTC Management Partners, LLC's** intranet. VPTC Management Partners, LLC shall provide a high speed connection at a VPN box at the site for this purpose. The contractor will facilitate a successful connection to this high-speed device.
 4. The BAS shall consist of the following components and equipment:
 - a. Distributed Microprocessor based remote control panels interfacing directly with sensors, transducers, and relays.
 - b. A communication network to allow data exchange between remote panels and between remote panels and personal computer operator workstations.
 - c. Laptop computer operator workstation, PC Operator workstation or user interface as specified, with all monitoring, programming, control and service software.
 - d. An Internet based paging system to allow alarming of building operators.
 - e. Application-specific controllers (ASC) sent to the manufacturer of the equipment controlled for factory installation, or field install by the BAS contractor.
 - f. Provide labor, hardware and software necessary to assist with the contractor performing Test and Balance work.
 - g. Provide miscellaneous temperature controls and manufacturer required control wiring for mechanical equipment as described in the specification and on the drawings.
 - h. Complete start-up, commissioning, testing and owner instruction as specified herein.

1.6 COORDINATION WITH OTHER TRADES

- A. Products furnished under this section but not necessarily installed by the TCC. Confirm with the mechanical contractor at the time of bid who is responsible. Bid to be broken out so that it reflects a detailed scope of work and any products being provided, installed or both by the TCC.
1. Flow switches
 2. Flow meters
 3. Pressure switches
 4. Temperature sensors
 5. Control damper actuators unless directed otherwise by mechanical contractor.
 6. Air-flow measuring stations
- B. Devices, system and components wired under this section. Confirm with the mechanical contractor at the time of bid who is responsible. Bid to be broken out so that it reflects a detailed scope of work and any products being provided, installed or both by the TCC.
1. All control damper actuators including installation of the actuator unless otherwise specified by the mechanical contractor
 2. All control valve actuators
 3. All air-flow measuring stations.
 4. Power wiring to all BAS panels from spare circuits in electrical panels. See electrical panel schedules for circuit locations.
 5. Miscellaneous temperature controls and control wiring per wiring diagrams submitted by the contractor providing the equipment and control devices.
 6. Wiring interface between all duct smoke detectors and MCC or unitary equipment.
 7. Field wiring of control devices provided with boilers.
 8. Field wiring of control devices provided with chillers.
 9. Field wiring of control devices provided with cooling towers.
 10. Field wiring of control devices provided with terminal units.
 11. Field wiring of control devices provided with rooftop units.
 12. Field wiring of control devices provided with VFDs.
- C. The following will be coordinated with other Division 15 trades:
1. Installation and or wiring all control damper actuators per direction of the contractor providing the dampers.
 2. Wiring all control valves actuators per the direction of the contractor providing the valves.
 3. Installation and wiring of all air-flow measuring stations and necessary.
 4. Installation and wiring of all flow switches including reducers and accessories.
 5. Installation of all pressure and temperature sensor wells and sockets.
 6. Variable Frequency Drive (VFD) interface.
 7. Integration of all unitary and terminal equipment.

8. Wiring interlock (non fire alarm) of the smoke detectors providing under Section 15950.

D. The following will be coordinated with other Division 16 trades:

1. Availability of circuits for powering all controllers.
2. Power wiring for all mechanical equipment and line voltage interlocks.
3. Interfacing with lighting control contactors/panels.
4. Interfacing with Division 16 provided VFDs.
5. Interfacing with digital electric metering.
6. Necessary interlock wiring between duct smoke detectors and the motor controllers or unitary equipment.

1.7 APPROVED BAS CONTRACTORS AND MANUFACTURERS

A. Acceptable system integrators and manufacturers will be determined based upon compliance with the terms of the specification. All prospective contractors will submit a Request for Qualification in accordance with Part 1 of this specification representing their compliance with the specification.

B. The acceptable contractor will meet the following requirements:

1. Have a minimum of five (5) years experience in the installation of LON based BAS comparable in size and scope to the system to be installed on this project.
2. Have a minimum of five (5) years experience in servicing a LON based BAS comparable in size and scope to the system to be installed on this project.
3. Meet all of the requirements of the Quality Assurance section of Part 1 of this specification and document this compliance in the request for quality as described in Part 1 of this specification.
4. Submit a list of reference projects as noted in the Quality Assurance section of Part 1 of this specification.
5. Provide documentation of training received by proposed project personnel on the installation, servicing, programming and designing of open protocol systems LON standard that is applied to this project. This training documentation will include any certification received from the governing body of the open standard or designated entity of the governing body.

C. The acceptable manufacturer will meet the following requirements:

1. Compliance with all applicable sections of this specification.
2. Letter of compliance with governing body of open protocol used by the manufacturer.

3. Available of controller product through multiple sources. Compliance with this requirement will be determined by the ability of building operations staff to procure equipment directly from at least two different suppliers. Agreements by which supplier A can obtain product from supplier B, and supplier A and B are listed as the multiple sources, will not be accepted. Sources must obtain product directly from the manufacturer.
- D. System integrators can use only products that comply with the requirement for LonWorks communication as noted in this specification.
- E. Systems which employ BacNet or proprietary controller communication at any level will not be considered unless VPTC Management Partners, LLC has previously approved the products as directed under Section 1.9 of this specification.

1.8 QUALITY ASSURANCE

- A. The System Integrator shall be experienced in the installation of the LON based DDC system as specified, shall submit at time of bid, as part of a request for Qualification described in Part 1 of the specification a list of no fewer than five (5) installations completed in the previous 18 months that demonstrate the level of expertise in the field. The system shall be installed by competent mechanicals, and electricians employed by the installing Contractor, or regularly subcontracted by BAS Contractors with full responsibility for proper operation of the BAS including debugging and proper calibration of each component in the entire system. The Contractor shall have an in-place support facility within 50 miles of the project, with technical staff, and all necessary test and diagnostic equipment to provide full support of the installed BAS.
 1. At least five of the references must be completed projects that demonstrate the use of a standard Internet browser (such as Netscape or Internet Explorer) as a means to access information from the BAS without use of proprietary hardware, software or interface devices.
 2. At least three of the reference installations must be completed projects that demonstrate the integration of products from at least three manufacturers at the Network level. Integration must be demonstrated without the use of gateways, workstations, or proprietary hardware or software. Controllers from multiple manufacturers must reside on the same network bus, they must communicate using the LON protocol, and the operator must be able to communicate with each controller through the use of a standard Internet browsing software (such as Netscape or Internet Explorer). In addition, controllers must use the same network management and configuration tools and database.
 3. References shall demonstrate the Contractor's compliance with the Approved System Integrators and Manufacturer's portion of Part 1 of this specification.
- B. The controllers and other controller-related products of the BAS system shall be LonWorks as specified in this specification. Substitutions are not allowed.
- C. The BAS System Installation shall consist of all necessary electric and DDC control and sensing devices as required and all accessories and electric wiring to fulfill the intent of the specification. All equipment to be furnished as part of this work shall be new and in conformance with all applicable standards and codes; unless noted otherwise elsewhere in the documentation.
- D. ISO-9001

1. The manufacturer of the Building Automation System (BAS) shall provide documentation supporting compliance with ISO-9001 (Model of Quality Assurance in Design/Development, Production, Installation, and Servicing). Product Literature provided by the BAS manufacturer shall contain the ISO-9001 Certification Mark from the applicable registrar. Manufacturers delivering products that do not comply with the IS-9001 certification requirement shall provide the following information to assure that quality systems are in place which are equivalent to the Iso-9001 standard:
 - a. Marketing Specification Standards
 - b. Design File Standards
 - c. Manufacturer Test Standards
 - d. Calibration Standards
 - e. Quality System Standards
 - f. Quality System Procedures
 - g. Documented management commitment that all employees participate in quality programs.
 - h. Training Procedures.
 - i. Methods by which corrective actions are taken for problems identified within the factory process.

- E. All system components shall be fault tolerant.
 1. Provide satisfactory operation without damage at 110% and 85% of rated voltage and at +/- 3 Hertz variation in line frequency.
 2. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static transients and inducted magnetic interference. Bus connected devices shall be AC coupled or equivalent so that any single device failure will not disrupt or halt bus communication.
 3. All real time clocks and volatile data files shall be battery backed up.

1.9 REQUEST FOR QUALIFICATION

- A. The Request for Qualification will include at a minimum:
 1. List of all proposed equipment including specific part numbers.
 2. Detailed manufacturer data sheets.
 3. Description of every aspect in which the proposed devices differ from the specified device.
 4. A summary statement of how the proposed system will function or how the substitution will impact the design of the system and its installation.
 5. For DDC controllers and software, examples of custom programs, graphic screens, and service tools required.
 6. A riser diagram of the proposed system including indication of communication protocols employed at each level of communication.
 7. List of five (5) reference projects as noted in the Quality Assurance section of this specification.
 8. List of all certified System Integrators currently employed by the BAS contractor, the original date of certification and the initial date of employment at the BAS contractor.
 9. List of two (2) of the above certified System Integrator that will be assigned to this project.

10. Passing Certificate for LonMark Certified Network Design, Programming, Configuration, Installing, and Maintenance Training Program.
11. Passing Certificate for Tridium Technical Certification Program and Niagara Certification Class.

B. Submit Qualifications within 14 days of Notice of Award.

1.10 SYSTEM PERFORMANCE

A. The system shall conform with the following:

1. Graphic Display. The system shall display a graphic with a minimum of 20 dynamic points with all current data within 10 seconds.
2. Graphic Refresh. The system shall update a graphic with minimum of 20 dynamic points with all current data within 8 seconds.
3. Object Command. The maximum time between the command of a binary object by the operator and the reaction of the device shall be less than 2 seconds.
4. Object Command. The maximum time between the command of an analog object by the operator and the start to adjust should be within 2 seconds.
5. Object Scan. All changes of state and change of analog values will be transmitted over the high-speed network such that any data used or displayed at a controller or workstation will have been current within the previous 6 seconds. This does not apply to information obtained from a gateway to a third-party manufacturer.
6. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 45 seconds.
7. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
8. Performance. Programmable controllers shall be able to execute DDC PID control loops at a selectable frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
9. Multiple Alarm Annunciations. All workstations on the network must receive alarms within 5 seconds of each other.
10. Report Accuracy. The system shall report all values with an end-to-end accuracy as listed, or better, than those listed in
 - a. Space Temperature – Reported Accuracy +/- 0.3 °F.
 - b. Ducted Air Temperature - Reported Accuracy +/- 0.3 °F.
 - c. Outside Air Temperature - Reported Accuracy +/- 0.3 °F.
 - d. Water Temperature - Reported Accuracy +/- 0.3 °F.
 - e. Delta-T - Reported Accuracy +/- 0.25 °F.
 - f. Relative Humidity - Reported Accuracy +/- 3% RH
 - g. Airflow (terminal) - Reported Accuracy +/- 10% of full scale
 - h. Air Pressure (ducts) - Reported Accuracy +/- 0.1 in. w.g.
 - i. Air Pressure (spaces) - Reported Accuracy +/- 0.1 in. w.g.
 - j. Electrical (A, V, W, Power Factor) - Reported Accuracy +/- 5% of reading
11. Stability of Control. Control loops shall maintain measured variable at set point within the tolerances.
 - a. Air Pressure - +/- 0.2 in.w.g. range of medium 0 to 6 in. w.g.
 - b. Air Pressure - +/- 0.01 in.w.g. range of medium -0.1 to 0.1 in. w.g.

- c. Airflow - +/- 10% of full scale
- d. Space Temperature - +/- 1.0 °F.
- e. Duct Temperature - +/- 1.5 °F.
- f. Relative Humidity - +/- 5% RH

1.11 SUBMITTALS

- A. Contractor to provide shop drawings and all other submittal information on all hardware, software and installation to be provided. No work may begin on any segment of this project until submittals have been successfully reviewed for conformity with the design intent. Provide a minimum of (6) copies of any submittal information.
- B. All drawings shall be prepared on a CAD system that produces drawing files compatible with AutoCad 2000 or higher and be provided on magnetic/optimal disk and as full size hardcopy drawings.
- C. On manufacturer data sheets (cut sheets), the data specifically applicable to the project shall be highlighted or clearly indicated by other means.
- D. Each submitted piece of literature, drawings, spreadsheets, etc. shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements.
- E. Submittals must have numbered or labeled tabs separating different sections and must have a table of contents indicating the information provided in the submittal and the tab under which the information can be found.
- F. Submittal #1: Within two weeks of contract award or letter of intent, submit the proposed system architecture including the following:
 - 1. Riser diagram showing the following:
 - a. Location of all network level controllers and SLC (see Part 2 of this specification for details)
 - b. Path of all communication networks including labeling of protocols used
 - c. Location of servers
 - d. Location of all routers (if necessary)
 - 2. Product information sheets for all network level controllers, servers, workstations, and routers (if necessary). Clearly mark the submitted sheet to indicate which options or features are included, and mark the sheet to reference tag numbers from the riser diagram.
 - 3. Letter verifying LON compliance of network level controller, server and workstation.
- G. Within thirty (30) days of contract award, review the field conditions and report any condition that would require modifications to the design drawings. In addition, prior to starting the installation, the Contractor shall provide:
 - 1. A project schedule showing the sequence and duration of tasks associated with the completion of the control system as specified herein including the critical path of completion.
 - a. This schedule shall highlight delivery dates for major items such as building controllers, control panels, completed software programs, building workstation, graphics, etc.

- b. In addition, the schedule shall clearly indicate which dates are directly affected by the work of other trade contractors.
 - c. A monthly report shall be provided. This report will include status of major delivery items, and an update of the schedule based upon the amount of work completed by the control system contractor as well as other contractors whose completion directly affects the completion of the control system installation.
2. Listing of the cable manufacturers and part numbers for all of the various cabling to be performed. The list should provide information for each wiring application required of the installation (e.g. Ethernet backbone, ASC network, space temperature sensors, etc.)
3. Description of methods for performing field quality control during the installation process.
4. Description of methods of testing and verifying integrity of installation after it has been completed, as well as checklist and report formats that will be used to comply with the “Demonstration and Acceptance” portion of Part 3 of this specification.
5. Product information sheets for all equipment and interface devices not supplied in the first submittal. Clearly mark the submitted sheet to indicate which options or features are included, and mark the sheet to reference tag numbers from the riser diagram.
6. Contractor-created, detailed sequence of operation showing all modes of operation and algorithms and including all software variables and flags used to complete the program. The sequence of operation will include software point, variable and flag names where referenced, detail all time delays, deadbands, setpoint ranges, etc., and describe all interactions and modes of operation. A sequence which copies the language of this specification will not be accepted.
7. Material lists.
8. Detailed point list showing nomenclature, point/panel assignments, descriptive titles, and devices.
9. Equipment schematics of all HVAC equipment showing all sensors and control devices and the reference numbers.
10. Controller wiring diagrams showing wiring to each controller. All wiring associated with a single controller should be shown on a single drawing.
11. Interface panel diagrams showing all wiring and devices.
12. Detail wiring diagrams showing all interface wiring.
13. Control Damper Schedules: Spread sheet type schedule shall include a separate line for each damper and a column for each the following damper attributes in the order presented here (no omissions);
 - a. Damper Tag
 - b. System
 - c. Service
 - d. Opening size (w x h)
 - e. Design Flow Rate (in CFM)

- f. Design Velocity (in FPM)
 - g. Damper leakage (in %)
 - h. Selection Damper Size (w x h)
 - i. Selection Labels & Sizes (w x h)
 - j. Manufacturer
 - k. Part Number
 - l. Blade Pattern (parallel, opposed, single)
 - m. Blade Type (e.g. air foil, two piece)
 - n. Bearing Type
 - o. Fail Position (de-energized) (e.g. open, closed, last position)
 - p. Actuator Manufacturer
 - q. Actuator Model Number
 - r. Actuator Quantity
 - s. Actuator Working Range (in Volts, mA or PSI as applicable)
 - t. Actuator Mounting Location (electronic; shaft, sleeve-out collar channel support, duct, wall, floor, jack shaft)
 - u. Damper Closing Torque
 - v. Actuator Rated Torque
 - w. Damper Close-Off Pressure (against system)
 - x. Comments
 - 1. Leakage and flow characteristics charts shall be submitted for review.
 - 2. Submit diagram for each damper of three or more sections wide showing the position of each section and associated actuator mountings.
14. Control Valve Schedules: Spread sheet type schedule shall include a separate line for each valve and a column for each the following valve attributes in the order presented here (no omissions);
- a. Valve Tag
 - b. System
 - c. Service
 - d. Piping System Pressure Rating
 - e. Pipe Size
 - f. Body Pattern (e.g.. straight thru, mixing, diverting)
 - g. Load (coil) Flow Rate (in GPM) (actual from submittals)
 - h. Load (coil) Pressure Drop (in PSI) (actual from submittals)
 - i. Desired Valve Pressure Drop
 - j. Calculated Valve Cv
 - k. Selected Valve Cv
 - l. Actual Valve Pressure Drop (in PSI)
 - m. Manufacturer
 - n. Part Number
 - o. Body Style (e.g. globe, butterfly, ball)
 - p. Pressure rating of valve body
 - q. Size (in inches)
 - r. Operating/Dynamic pressure rate of valve
 - s. Pipe Connections (sweat, screwed, flanged)
 - t. Fail Position Flow Pattern (de-energized) (e.g. open, closed, last position, thru coil, bypass coil)
 - u. Actuator Manufacturer
 - v. Actuator Model Number
 - w. Actuator Working Range (in Volts, mA or PSI as applicable)
 - x. Actuator Close-Off Pressure (against system)

H. Within sixty (60) days or contract submit:

1. Sample of all reports.
 2. An alarm schedule noting (for each alarm in the system): alarm class, description, operator action required, priority, time delay, auto/manual reset, limit levels (Analog Alarms), whether the operator can disable the alarm, paging code.
 3. Sample of graphics and a list of all graphics to be provided including a flow chart showing the organization of the graphics.
 4. List all control programs with description.
 5. List all setpoints, with descriptions and default values.
 6. Training manuals including a course outline and schedule for all training to be provided. **VPTC Management Partners, LLC** shall review and return the training outline and provide dates for the various training sessions spelled out in Part 3 of this specification.
- I. By no later than thirty (30) days prior to start-up, submit:
1. Complete software program in editable form.
 2. All reports.
 3. All graphics.
 4. A contactor name and 24-hour emergency number of a representative of each company associated with the control system installation.
 5. Operations manuals for all equipment installed on the job.
 6. A list of recommended spare parts.
 7. Recommended preventative maintenance procedures for all equipment installed as part of this project.
 8. All licenses, guarantees and warranty documents.
- J. Upon completion of the installation, the Contractor will provide (3) copies of the project record documents which shall include:
1. A marked-up set of contract documents noting any changes from the contract documents.
 2. Testing and Commissioning Reports and Checklist to satisfy the requirements of Start-up and Commissioning as discussed in Part 3.

1.12 WARRANTY

- A. All components, parts and assemblies supplied by the Contractor shall be guaranteed against defects in materials and workmanship for two years from the date of substantial completion. Service shall be provided within 24 hours of notification from **VPTC Management Partners, LLC**. During normal building occupied hours service on items deemed critical for system operation shall be provided within 4 hours of notification from **VPTC Management Partners, LLC**.
- B. Labor to troubleshoot, repair, or replace system components installed by this Contractor shall be furnished by the Contractor at no charge to **VPTC Management Partners, LLC** during the construction and warranty period. If within two (2) years from the date of completion any of the equipment herein described is defective in operation, workmanship or materials, it will be replaced, repaired or adjusted at the operation of the BAS Contractor free of charge, provided that the defect is reported within (30) days of failure occurrence.
- C. At the end of the final start-up, testing, and commissioning phase, if equipment and system are operating satisfactorily to **VPTC Management Partners, LLC**, **VPTC Management Partners, LLC** shall sign certificates certifying that the control system's

operation has been tested and accepted in accordance with the terms of this specification. The date of acceptance shall be the start of warranty.

- D. Exception: The Contractor shall not be required to warrant reused devices, except for those that have been rebuilt and/or repaired. The Contractor shall warrant all installation materials and labor, however, and shall demonstrate that all reused devices are in operation condition at the time of acceptance by **VPTC Management Partners, LLC**.
- E. If **VPTC Management Partners, LLC** receives substantial use of a phase of the project prior to completion of the entire project, the Contractor can request that the portion being used receive a phased acceptance. If **VPTC Management Partners, LLC** agrees, the warranty period for this phase of the project will begin at the date of phased acceptance. However, this does not relieve the Contractor of fully commissioning this phase of the work, and if, during the final phase of commissioning, demonstration or acceptance, an error is found in the phase of the installation under substantial use, and this error is attributable to the installation by the Contractor, then the Contractor will correct this error at no cost for **VPTC Management Partners, LLC** regardless of the status of the warranty for that phase of work.

1.13 OWNERSHIP OF PROPRIETARY MATERIAL

- A. All project-developed software and documentation shall become the property of **VPTC Management Partners, LLC**. These include, but are not limited to:
 - 1. Project graphic images
 - 2. Record drawings
 - 3. Project database
 - 4. Project-specific programming code
 - 5. All documentation
 - 6. Network management tools
 - 7. Device configuration tools
 - 8. Device programming
 - 9. Tridium Niagara tools
 - 10. Any other tools, taking the form of software, hardware, firmware, or documentation that was used in the development, programming, or commissioning of this project.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. All products used in this project installation shall be new and currently under manufacture and shall have been applied in similar installations. This installation shall not be used as a test site for any new products unless explicitly approved by **VPTC Management Partners, LLC** in writing.
- B. Spare parts shall be available for at least five years after completion of the contract.

2.2 COMMUNICATION

- A. The system will utilize TCP/IP 100MB Ethernet on a new LAN installed as part of this project. All network area controllers (NAC), workstations and servers will reside on the Ethernet LAN.
- B. Communication among the network level controllers will be use TCP/IP over 100MB Ethernet. It will be full peer-to-peer communications. No exceptions to this requirement will be considered.

- C. All communication between NAC and system level controllers (SLC) and between NAC and application specific controllers (ACS) will be LonWorks. No exceptions to this requirement will be considered. The communication network between NAC and SLC and between NAC and ACS must support similar products from other manufacturers such that the two products can reside on the network at the same time, communicate with the NAC, and provide all necessary information to the Web server without the use of a Gateway. The Contractor installing the BAS must show, in accordance with the Quality Assurance section of Part 1 of this specification that multiple manufacturers' products can reside on this network and use the same network management and configuration tools and database.
- D. Communications between the server and all NAC shall be TCP/IP, XML over the 100MB Ethernet **VPTC Management Partners, LLC** LAN. This connection is accomplished through a VPN firewall router which shall be provided by **VPTC Management Partners, LLC**. The BAS contractor shall allow set up time within their bid for the configuration of the NAC and the provided VPN router.
- E. Communications between the server and the workstations shall be HTTP and HTML. All workstations will run Microsoft Internet Explorer or industry-standard browser software. The server will communicate with the NAC and serve up information to the workstations.
- F. Every NAC must be capable of transmitting a message to a specific NAC/SLC/ACS as well as to all NAC/SLC/ASC.
- G. All messages transmitted must be positively acknowledged as received. Lack of acknowledgments shall immediately force a re-transmission of a message.
- H. Error recovery and communication initialization routines are to be resident in each bus-connected device.
- I. Message and alarm buffering must be present to prevent information from being lost.
- J. Other than sensor/data sharing (with proper failure default procedures), under no circumstances shall DDC programs be LAN communications system dependent. Any DDC programs which require data from the communication system shall have default values for use in the DDC control loop in the event of failure to obtain data from the LAN communication system.
- K. LAN communication system shall have default detection capability to assist in locating breaks in the communication cable when they occur.
- M. The LAN and NAC communications shall be multiple-user, allowing operators on different workstations to talk to the same or different NAC at the same time.

2.3 OPERATOR INTEFACE

- A. The operator interface will be via workstations residing on the building LAN and **VPTC Management Partners, LLC's** WAN or an integrated operator interface. They will run industry standard web browser software such as Microsoft Internet Explorer, Netscape, Firefox, etc.
 - 1. The interface will be graphically based and allow multiple windows, viewing different part of the system, to be displayed and updated simultaneously.
 - 2. Provide multi-level password-protected access to the system. Definition of user passwords will governed by the highest level of user and shall not be resident in

- any single workstation, but rather, in a centralized location that can be adjusted from any location by the appropriate user.
3. Provide any operator commands, adjustability, acknowledgement or other functionality required by the sequence of operations. (i.e. Operator shall be able to adjust all setpoints, schedules, alarm limits, etc. as noted in the sequence of operation.)
 4. The system shall trend any input, output or calculated value upon operator command and provide user definable reports. Provide the trend logs and reports as noted in Part 3 of this specification.
 5. Store alarms in the building controllers, and report to the operator workstations as soon as the interface is established, or immediately if connection exists.
 - a. Buffering: The system controllers must be able to store alarms for a minimum of 5 days without connection of the operator interface. Alarms must be automatically download to a file on the operator workstation prior to the alarm buffering reaching 80% capacity. This can be accomplished by an automatic routine that notifies the user of its completion prior to clearing the buffer, or by means of an automatic prompt to the operator asking if they would proceed with buffer download.
 - b. Alarms will be provided in accordance with the sequence of operations. All alarm descriptions will have default values as described in the sequence of operations, but shall be user adjustable by the highest level user.
 - c. Display alarm description, time of alarm, system of alarm, current state and status of acknowledgements.
 6. System software will provide direct exchange of information into industry-standard spreadsheets and database programs such that the user can link points to the program and the information will update automatically. Trend logs, reports and alarms shall be directly exportable to industry-standard spreadsheets and database programs.
 7. All information and graphic loading shall be in accordance with the System Performance section of Part 1 of this specification.
 8. Actions such as schedule adjustment, password changing, setpoint adjustment and alarm acknowledgement will be logged by user performing the action, time and date action.
- B. The remote interface will be via the **VPTC Management Partners, LLC's** WAN through workstations running industry-standard web browser software such as Microsoft Internet Explore, Netscape, etc. for a minimum of five simultaneous users.
- C. The system will employ a web server that resides on the LAN. This server will serve up pages read through the industry-standard web browser.
- D. The server will serve up all of the graphics and data needed to display system information on the browsers. The server will provide all necessary applets (JAVA) to allow browsers to display data as needed.
- E. The operator interface will be installed and configured such that it will be capable of connecting to any LonWorks product that has been routed to TCP/IP. See the Integration with Third-Party Manufacturer's Equipment section of the specification for more details.
- F. Provide **VPTC Management Partners, LLC** all licenses and any source code for custom programs created for this project. Also provide a library of standard programs and programming blocks with documentation to allow for their use.
- G. Integration of products from multiple vendors must not rely on a workstation or the web server. Any communication between controllers will occur via a standard protocol and will

be independent of the workstation and web server. Systems that require a workstation or third-party hardware or software to link products from different manufacturers will not be permitted.

- H. The operator interface (NAC) shall be Tridium Niagara.
1. The Bas Contractor shall provide as part of the submittals a copy of the Niagara Compatibility Statement (NiCS) verifying that all aspect of the Niagara Framework maintains an Open System Design. The System as provided shall confirm with the following NiCS:

<u>Property</u>	<u>Value</u>
Station Compatibility In	All
Station Compatibility Out	All
Tool Compatibility In	All
Tool Compatibility Out	All

2.4 WORKSTATION AND OPERATOR INTERFACES

The contractor will coordinate with VPTC Management Partners, LLC what of the following interface items shall be provided with the project.

- A. Provide Touch Screen Terminal.
1. Industrial PC with a 1.0 GHz Intel Celeron M ULV Processor
 2. On board Graphic Adapter, Intel Extreme Graphic
 3. 1 GB DDR Ram
 4. 64 MB Compact Flash Drive
 5. (2) Independent Ethernet interfaces
 6. 24V DC Power Supply
 7. TFT display 12-inch, 800x600 Laminate variant is display only
 8. Operating system Windows XP Professional Embedded
 9. Installation in the front of a control cabinet.
 10. Acceptable manufacturer:
 - a. Beckhoff Automation #6201-0001-0000
 - b. Or equal
- B. Provide a Dell workstation with the minimum requirements:
1. Pentium-4 with a minimum 2GHz processor speed
 2. 1 G Bytes of RAM
 3. CD-ROM R/RW drive
 4. DVD-R/RW drive
 5. 80 GB hard drive
 6. 22" Flat Panel color monitor (note: simply providing a flat screen monitor is unacceptable)
 7. Mouse and keyboard
 8. USB port
 9. Ethernet port
 10. Windows XP Professional operating system
 11. Include original printed manuals for all software and peripherals
 12. Include original installation disks for all software, device drivers and peripherals
 13. Provide software registration cards to **VPTC Management Partners, LLC** for all included software
 14. HP Color Laser printer or equal
- C. Provide software on this workstation to do the following functions.

1. Program controllers (NLC & SL)
 2. Diagnose system and controllers errors.
 3. Generate and modify web graphics
 4. Configure controllers
 5. Compile and download controller programs. The controller programming language shall be graphical, object-orientated language.
- D. Provide a laptop computer capable of being plugged into a port on the network level controller of SLC's as noted in Part 3 of this specification. Provide an IBM, HP, Compaq, or Toshiba Personal Laptop Computer with the following minimum requirements:
1. Pentium-4 with a 2GHz processor speed
 2. PnP compliant motherboard
 3. 1 G Bytes of RAM
 4. CD-ROM R/RW drive
 5. DVD-R/RW drive
 6. 80 GB hard drive
 7. Keyboard with 83 keys (minimum)
 8. Windows XP Professional operating system
 9. USB port
 10. Ethernet port
 11. 17" SVAGA 800x600 resolution active matrix display with 64K colors
 12. Two PCMCIA Type II or One Type III card slot
 13. Memory management software providing a minimum of 600K available base memory and EMS and XMS management services.
 14. Include original printed manuals for all software and peripherals
 15. Include original installation disks for all software, device drivers and peripherals
 16. Provide software registration cards to **VPTC Management Partners, LLC** for all included software
 17. Carrying Case
 18. Spare battery
 19. External power supply/battery charger.

The laptop shall utilize the standard operator workstation software as previous defined and shall be configured by the BAS Contractor for remote access as part of the training session.

- E. Hand-Held Terminal
1. Terminal shall access all points connected to an ACS.
 2. Provide user-friendly keypad interface or touch screen menus that instruct the user as they manipulate the device.
 3. For systems that do not operate on standard batteries, provide a spare battery and re-charger.
 4. The portable operator terminal when used to access Terminal Unit Controllers shall utilize either the standard operator workstation software as previously defined or controller specific utility software.
 5. Controller specific utility software shall at a minimum allow for monitoring/configuring of the following:
 - a. View/Modify All Point Values
 - b. View/Modify All Software Parameter Values
 - c. View/Configure Alarms
 - d. View/Configure Historical Data Trending
 - e. View/Modify Schedules
 - f. Security
 - g. System Commissioning

- h. Upload/Download/Modify controller programs and database information

2.5 BUILDING CONTROLLERS

- A. There are three levels of controllers specified: Network Level Controllers (NAC), System Level Controllers (SLC) and Application Specific Controllers (ASC). See the System Performance section of Part 1 of this specification for details about controller accuracy for the various controlled variables.
- B. Network Level Controllers (NAC)
 - 1. The NAC shall be of the Niagara –AX platform type
 - 2. NAC shall reside on the 100MB Ethernet, and communicate with TCP/IP. If the NAC is not native 100MB Ethernet, provide any necessary routers. No exceptions to these requirements will be considered.
 - 3. The NAC shall have ports as needed to communicate with SLC's, ACS's or any laptop computers that may be required.
 - 4. The NAC may or may not have on-board I/O point capability. If it has I/O, and all I/O shall meet specifications for SLC I/O.
 - 5. Each NAC shall have a static IP address.
 - 6. No more than (60) Nodes shall be allowed for each NAC. Whereas node counts are above (60), the BAS contractor shall provide additional NAC's and related cabling, routers, switches, etc. required for a full functional system.
 - 7. Provide complete documentation of all LonWorks compliance with the first submittal (See the Submittal section of Part 1)
 - 8. NAC's shall be used to provide all points for all equipment not specifically specified to be controlled by an ACS.
 - 9. Acceptable manufacturers:
 - a. Tridium-Niagara-Jace-AX
 - b. Honeywell – WEBS Jace–AX
 - c. Or equal
- C. System Level Controllers (SLC)
 - 1. SLC's shall be used to provide all points for all equipment not specifically specified to be controlled by an ACS.
 - 2. SLC's can reside on a secondary communication bus as described in the communication portion of Part 2 of this specification.
 - 3. Provide complete documentation of all Lon Works compliance with the first submittal. (See the Submittals section of Part 1)
 - 4. Acceptable manufacturers:
 - a. Tridium-Niagara-Jace 2/ 6 - AX
 - b. Honeywell
 - c. Or equal
- D. Application Specific Controllers (ASC)
 - 1. ASC shall be used only on "unitary" equipment such as fan coil units, VAV boxes, Unit Ventilators, Heat Pumps or the equipment where only remote enable/disable/status is required.
 - 2. Each piece of equipment served by an ACS must have its own, dedicated ASC.
 - 3. Provide complete documentation of all Lon Works compliance with the first submittal. (See the Submittals section of Part 1)
 - 4. Acceptable manufacturers:
 - a. Honeywell
 - b. Or equal

- E. Status Indication: NAC and SLC shall have status indication. All digital outputs shall have LED indication the actual status of the output (i.e. whether command or overridden by switch). NAC, SLC and ASC shall have an LED indicating that power is connected.
- F. All control logic shall reside in NAC, SLC or ACS for all points connected to that controller (no dummy I/O). The only control logic that is dependent on another controller should be shared data (i.e. OA Temp, Enthalpy Flag, Schedules and Electrical Demand).
- H. Operator Interface: There shall be a jack for connecting of a POT at each controller. The POT should be able to monitor all points on the network if connected to an NAC. At SLC and ASC, the POT should be able to monitor all local points to that controller.
- I. Spare Capacity: Provide spare capacity as detailed in Part 3 of this specification. Future use of spare capacity shall require providing the field device, field wiring, point database definition, and custom software. No additional controller boards or point modules shall be required to implement use of these spare points.
- J. Memory Back-up: Each controller should have its volatile memory backed up by a 72-hour battery. Batteries shall be lithium. In case of memory loss, all controllers shall be capable of being reloaded by a workstation or POT. Loss of power, memory, or communications at any controller shall generate an alarm at the workstation.
- K. Internal clock: The real time clock in all NAC's shall have internal calendar with automatic leap year capability to provide time of day, day of week and date. Clocks shall operate under back-up power.
- L. Surge and Transient Protection: Isolation must be provided at all network terminations, as well as field point terminations to suppress inducted voltage transients consistent with IEEE Standard 587-1980.
- M. Power-fail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software.
- N. All panel electrics shall be installed in finished steel cabinet. Interface panels shall have hinged doors and shall also contain all load relays, transducers, and associated equipment. All cabinets shall be of adequate size to accept 20% space capacity. Provide spare capacity at each cabinet for future expansions and identify quantity of spare capacity in submittal #2 as described in Part 1 of this specification. Provide one 120V duplex convenience outlet within the confines of the cabinet or adjacent to the cabinet.

2.6 INPUT/OUTPUT INTERFACE

- A. Input/Output sensors and devices shall be closely matched to the requirements of the controllers for accurate, responsive, noise free signal input/output. Control input shall be highly sensitive and matched to the loop gain requirements for precise and responsive control. In no case shall computer inputs be derived from pneumatic sensors.
- B. See the System Performance section of Part 1 of this specification for information about sensor accuracies.
- C. Temperature sensors shall be Resistance Temperature Detector (RTD) type, or 10,000 Ohm thermistors.
 - 1. Space temperature sensors shall be provided with blank commercial type finished decorative locking covers. Space temperature sensors in private offices shall have means for setpoint adjustment. Limits to adjustment, shall be adjustable from workstation. Sensors in public areas will have no adjustments.

2. Duct temperature sensors shall be rigid stem at least 9" long.
 3. Duct averaging sensors shall be a minimum length of two times the maximum duct dimension.
 4. Water sensors shall have separate copper or stainless wells.
 5. Outside air sensors shall be located in a mechanically aspirated enclosure. Accuracy of the sensor is to include all inaccuracies of the sensor, transmitter (if used), line losses, input resolution, A to D converter, and conversion equations. Please itemize all of these accuracies in submittals (see the Submittals section of Part 1 of this specification for details).
 6. Sensors shall be linear unless controller has built in conversion algorithms for non-linear sensors.
- D. Air and water pressure transducers shall be sized such that the resolution of the signal measured will be appropriate for the application. Range of input signal shall not be less than 50% of the measuring range of the transmitter, and maximum value of the input signal shall not be less than 75% of the measuring range of the transmitter.
1. Acceptable manufacturers:
 - a. Bapi
 - b. Mamac
 - c. Veris
 - d. Manufacturer specific
 - e. Or equal
- E. Control relays shall be suitable for the loads encountered.
1. Acceptable manufacturers:
 - a. Idec
 - b. Magnecraft
 - c. Omron
 - d. Or equal
- F. Supply and Return Duct Air Flow Measuring Stations
1. Air Measuring Stations to be furnished under this section of the specification and installed under Division 15 for Ductwork Accessories.
 2. Duct-mounted, airflow and temperature measurement. Thermal anemometer using instrument grade self-heated thermistor sensor with thermistor temperature sensors.
 3. Flow measurement drift shall not exceed Manufacturer's repeatability statement for the life of the equipment.
 4. Vortex shedding arrays are not acceptable. Pilot tubes and differential pressure sensing arrays are not acceptable. Sensors requiring auto-zeroing are not acceptable.
 5. Sensors shall be one glass encapsulated self-heated thermistor and one glass encapsulated thermistor temperature sensor for each sensing point.
 6. Sensor per probe shall be one to four depending on probe length. Sensor housing shall be Noryl.
 7. Warranty: 36 months from date of shipment, parts and factory labor.
 8. Factory start-up shall be included.
 9. Acceptable manufacturers:
 - a. DYBEC
 - b. Ebtron
 - c. KURZ
 - d. Or equal
- G. Outside Air Flow Measuring Stations
1. Provide a compact duct sleeve fabricated from 18 gauge galvanized steel, where indicated and scheduled. Sleeve shall be 18" deep and incorporate an opposed

- blade damper assembly, an airflow measuring station and 1.5" thick flow conditioner. Entire sleeve shall be factory assembled with all components.
2. The opposed blade damper assembly shall incorporate 6" aluminum airfoil type standard un-insulated blades. The damper shall be sized to provide sufficient pressure drop to ensure controllability. The damper actuator/s shall be a spring return type and conform to the mechanical section of Division 15.
 3. The airflow elements shall employ digital thermal technology and be capable of measuring flow rates from 0 to 5000 Ft/min. The temperature sensors shall be thermally excited glass encapsulated thermistor bead resistant to fouling by dirt.
 4. Providing the necessary microprocessor control panel interface to "daisy chain" the signals of all air flow monitoring stations to a single point. The microprocessor panel must be capable of producing individual analog output signals to the BAS. The panel shall include a backlit 80 characters multi-line alpha numeric display.
 5. An identification label shall be placed on each sleeve assembly listing the model No., System Served, Size and Identifying Tag Number.
 6. Factory start-up shall be included.
 7. Warranty: 36 months from date of shipment, parts and factory labor.
 8. Acceptable manufacturers:
 - a. DYBEC
 - b. Ebtron
 - c. KURZ
 - d. Or equal
- H. Static Pressure Traverse Probe
1. Duct static probes shall be provided where required to monitor duct static pressure.
 2. Acceptable manufacturers:
 - a. Dwyer
 - b. Mamac
 - c. Or equal
- I. Status and Safety Switches
1. General Requirements: Switch shall be provided to monitor equipment status, safety conditions, and generate alarms at the BAS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.
 2. Current Sensing Switches
 - a. The current sensing switch shall be self-powered with solid state circuitry and a dry contact output. It shall consists of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and a LED indicating the on or off status. A conductor of the load shall be passing through the window of the device. It shall accept over-current up to twice its trip point range.
 - b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
 - c. Current sensing switching shall be calibrated to show a positive run status only when the motor is operating under load. A motor with a broken belt or coupling shall indicate a negative run status.
 - d. Acceptable manufacturers:
 1. Functional Devices
 2. Setra
 3. Veris
 4. Or equal
 3. Air Filter Status Switches

- a. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 Amps at 120 VAC.
 - b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
 - c. Provide appropriate scale range and differential adjustments for intended service.
 - d. Acceptable manufacturers:
 1. Cleveland Controls
 2. Dwyer
 3. Or equal
4. Air Flow Switches
- a. Differential pressure flow switches shall be snap acting micro-switches with appropriate scale range and differential adjustment for intended service.
 - b. Acceptable manufacturers:
 1. Cleveland Controls
 2. Dwyer
 3. Or equal
5. Air Pressure Safety Switches
- a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 Amps at 120 VAC.
 - b. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.
 - c. Acceptable manufacturers:
 1. Cleveland Controls
 2. Dwyer
 3. Or equal
6. Water Flow Switches
- a. Differential pressure switches used to monitor air, water circuits shall be of the automatic reset type with SPDT contacts rated for 2 Amps at 120 VAC.
 - b. Provide appropriate scale range and differential adjustments for intended service.
 - c. Acceptable manufacturers:
 1. Cleveland Controls
 2. Dwyer
 3. Penn
 4. Or equal
7. Low Temperature Limit Switches
- a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 Amps at 120VAC.
 - b. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Elements shall be mounted horizontally across duct in accordance with manufacturing recommended installation procedures.
 - c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.
 - d. Acceptable manufacturers:
 1. Cleveland Controls

2. Dwyer
3. Penn
4. Or equal

- J. Moisture Sensors:
1. Provide moisture sensors in each penthouse containing water handling devices (pumps, heat exchangers, etc). These devices to be provided near each floor drain location.
- K. Carbon Monoxide and Dioxide Sensor
1. Minimum sensor range shall be 0-200PPM for CO and 0-2000PPM for CO₂, microprocessor controlled.
 2. Analog output capable of 4-20mA, 0-5VDC or 0-10VDC.
 3. LED indicators to display normal and alarm conditions
 4. Sensor element must be replaceable
 5. Incorporate an audible alarm
 6. One NC contact and one NO contact to provide an input to the BAS.

2.7 CONTROL DAMPERS

- A. All control dampers including air handler dampers may be provided under this section if required by mechanical contractor.
- B. Size all dampers and actuators for the appropriate application and submit this information on a damper schedule as noted in the Submittals section of Part 1 of this specification.
- C. All 2-position control dampers shall be duct size
- D. All modulating control dampers shall be sized by the contractor installing the BAS to allow for proper control and pressure drops.
- E. All control dampers shall be high performance ultra low leakage type.
1. Leakage shall be no more than 1% at 1500 FPM approach velocity at 4" static closing torque. Submit leakage and flow characteristics for all control dampers. Standard air leakage data to be certified under the AMCA certified ratings program.
 2. Damper blades to be extruded aluminum profiles. Blade ends to be capped in order to seal hollow interior and minimize air leakage possibilities.
 3. Blade gaskets and frame seals shall be extruded silicone. Gaskets to be secured in an integral slot within the aluminum extrusions.
 4. No blade shall be greater than 8" width or 48" length, and dampers shall be available for either opposed or parallel blade action.
 5. Frames shall be extruded aluminum (not less than 0.8" thick).
 6. Dampers to be designed for temperature ranging between -40 °F and +212 °F, and shall have a pressure drop of a full open 48"x48" damper shall not exceed .02"w.g. at 1000 FPM.
 7. Dampers shall be available in two mounting types: i.e. "Installed in duct" or "Flanged to Duct", and installation of dampers shall be in accordance with manufacturer's installation guidelines.
 8. All outside air and exhaust air dampers shall be internally insulated and thermally broken exposed to outdoor.
 9. Acceptable manufacturers:
 - a. Ruskin , Series CD 50 (Series CDT150BF for outside air, combustion air and exhaust air applications)
 - b. Tamco, Series 1500 (Series 9000 for outside air, combustion air and exhaust air applications)

c. Or equal

- F. Damper actuators shall be electronic and in accordance with the Section of Part 1 of this specification.
1. Actuators shall be direct-couple type capable of mounting to a damper shaft up to 1.05" O.D. without the need for linkage.
 2. Modulating actuators shall have true analog signal (2-10VDC). PWM, On/Off or Floating Point control is not allowed. Selecting of direct/reverse action relative to signal shall be accomplished by a switch mounted on the actuator, and shall not require opening the housing.
 3. Actuator shall fail closed (spring return) on loss of power for all OA and EA applications. Closing time shall be less than 30 seconds.
 - a. This cannot be accomplished by capacitor-type failsafe.
 - b. Changing of failsafe direction shall not require removal or reinsertion of drive mechanism.
 4. Actuators on isolation dampers shall have integral end switch to prove damper open.
 5. Provide a manual positioning of the damper actuator without power and without disconnection the actuator from the damper.
 6. Acceptable manufacturers:
 - a. Belimo
 - b. Delta
 - c. Manufacturer specific equal to "Belimo" type actuator
 - d. Or equal

2.8 CONTROL VALVES

- A. All control valves may be provided under this section if required by the mechanical contractor.
- B. Size all valves and actuators for the appropriate application and submit this information on a valve schedule as noted in the Submittals section of Part 1 of this specification.
- C. For valves 2" and less, use characterized ball valves, in accordance with Section 15100.
- D. For valves 2" to 4" use butterfly valves, in accordance with Section 15100.
- E. For valves larger than 4" use butterfly valves, in accordance with Section 15100.
1. Valve bodies shall be of the full lug-wafer style, drilled and tapped. The body shall feature an extended neck allowing sufficient clearance for flanges and piping insulation. Assemblies shall have a minimum resolution of 40 to 1. The disc shall be aluminum, bronze or stainless steel for steam applications.
 2. The disc shall have full 360 degree concentric seating. A torque plug shall provide a positive leak-proof connection of the disc to the stem. The seat shall be heavy duty with molded-in O-rings created a positive seal between flange face and valve body. No gaskets shall be required between the valve and flange faces. The resilient seat shall provide bubble tight shutoff in either direction with the disc closed. The seat shall be field replaceable and not bonded to the valve.
 3. Acceptable manufacturers:
 - a. Belimo
 - b. Delta
 - c. Or equal
- F. Valve actuators shall be electronic and in accordance with the Section of Part 1 of this specification.

1. Modulating actuators shall have true analog signal (2-10VDC). PWM, On/Off or Floating Point control is not allowed. Selecting of direct/reverse action relative to signal shall be accomplished by a switch mounted on the actuator, and shall not require opening the housing.
2. Actuator shall fail open (spring return) on loss of power for all hot water applications. Closing time shall be less than 30 seconds.
 - a. This cannot be accomplished by capacitor-type failsafe.
 - b. Changing of failsafe direction shall not require removal or reinsertion of drive mechanism.
3. Provide a manual positioning of the damper actuator without power and without disconnection the actuator from the damper.
4. Acceptable manufacturers:
 - a. Belimo
 - b. Delta
 - c. Manufacturer specific
 - d. Or equal

2.9 TRANSFORMERS AND POWER SUPPLY

- A. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuit for class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
- B. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load charges. Unit shall have built-in over and over-current protection and shall be able to withstand a 150% current overload for at least 3 seconds without trip-out or failure.
 1. Unit shall operate between 32 °F and 120 °F.
 2. EM/RF shall meet FCC Class B and VDE 0871 for Class B and MIL-STD 810C for shock and vibration.
 3. Line voltage units shall be UL recognized and CSA approved.
- C. Acceptable manufacturers:
 - a. Functional Devices
 - b. Lectro
 - c. Or equal

2.10 INTEGRATION WITH THIRD-PARTY MANUFACTURERS EQUIPMENT

- A. Provide the third-party interface as noted in Part 3 of this specification. Interfaces will map all points noted on the drawings or required by the sequences in Part 4 of this specification as a minimum, and all points available from the controller as a maximum. If a point listed in Part 4 cannot be integrated through the interface, then the Contractor is responsible to connect the point to the BAS through a hard wired input or output. If more points are available than are listed either on the drawings or as required by the specifications, then submit the available points for selection by **VPTC Management Partners, LLC**.
- B. LonWorks compliant NAC and manufacturer-provided controls.
 1. For controllers to be installed, provide any information necessary to **VPTC Management Partners, LLC** to allow another LonWorks compliant device to be directly connected to the existing network, and send/receive information to the system installed under this specification. The system shall then read and present the information made available by the third-party system, and transmit information receivable by the third-party system. This shall be accomplished by user

configuration of point information, but shall not require recompiling or downloading of control programs.

- C. Non-LonWorks compliant NAC and manufacturer-provided controls.
 - 1. Providing programming and hardware necessary to integrate information from the existing controllers as noted in Part 3 and 4 of this specification.
 - 2. For each system to be connected, provide a separate NAC.
 - 3. If information will not be available through integration, then the Contractor will include the cost to remove the existing controller hardware, replace with new NAC/SLC/ASC in accordance with Part 2 of this specification. This includes all programming, wiring, testing and commissioning as noted in this specification.
 - 4. Non-LonWorks compliant integration shall only be used if LonWorks compliant integration is not available.

PART 3 - EXECUTION

3.1 GENERAL

- A. The BAS shall be designed, installed, and commissioned in a turnkey fully implemented and operational manner; including all labor not noted in the Description of Work and Additional Work paragraphs of Part 1 of this Specification, and not noted in other Sections of this Specification.
- B. Install equipment, piping and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.
- C. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability and compatibility and be executed in strict adherence to local codes and standard practices.

3.2 EXAMINATION

- A. The project plans shall be thoroughly examined for control device and equipment locations. Report any discrepancies, conflicts, or omissions to **VPTC Management Partners, LLC** for resolution before rough-in work is started.
- B. The Contractor shall inspect the site to verify that equipment may be installed as shown. Report any discrepancies, conflicts, or omissions to **VPTC Management Partners, LLC** for resolution before rough-in work is started.
- C. The Contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate-or if any discrepancies occur between the plans and the Contractor's work and the plans and the work of others-the Contractor shall report these discrepancies to **VPTC Management Partners, LLC** and shall obtain written instructions for any changes necessary to accommodate the Contractor's work with the work of others. Any changes in the work covered by this specification made necessary by-and at the expense of-this Contractor.

3.3 PROTECTION

- A. The Contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.
- B. The Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The Contractor shall protect any material that is not immediately

installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

- C. The Contractor is made aware through this specification that work will occur in existing building areas that will remain occupied. All work will proceed with full protection of existing spaces and with minimal disruption of building tenants and employees. The Contractor shall be liable for any damage caused by their installation. The building staff will be responsible for normal housekeeping.
- D. Coordinate and schedule with **VPTC Management Partners, LLC**. Provide a weekly schedule that notes the progress of the prior week, and projects the progress of the next three weeks to allow for the coordination of work areas and to give **VPTC Management Partners, LLC** ample time to notify tenants and employees.

3.4 COORDINATION

A. Site

- 1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the Contractor shall assist in working out space conditions to make a satisfactory adjustment. If the Contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the Contractor shall make the necessary changes in his/her work to correct the condition without extra charges.
- 2. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

B. Submittals. Refer to Submittals in Part 1 of this specification for requirements.

3.5 FIELD QUALITY CONTROL

- A. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state and federal codes and ordinances as identified in Part 1 of this specification.
- B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship, and shall submit method for performing this monitoring in accordance with Submittals as discussed in Part 1 of this specification.
- C. Contractor shall have work inspected by local and/or state authorities having jurisdiction over the work.

3.6 CONTROL PANELS

A. Local Control Panels

- 1. Install control panels where shown and as indicated in documentation.
- 2. All digital controllers and control devices shall be mounted within NEMA 1, NEMA 4, or plenum rated enclosures as required by the location within the field.
- 3. All power supplies, points and interface devices for a given system that are not located at or on the equipment to be controlled shall be contained within a single control panel.
- 4. Where existing panels are to be re-used, replace any panel covers that have abandoned devices installed through the panel cover.

5. Where sequences require audio or visual notification, the horn, strobe, or other similar device shall be mounted on the control panel and labeled with a plastic, engraved label indicating the equipment alarm and whether the alarm is manual or automatic reset.
6. Control and status relays are to be located in designated enclosures only. These enclosures include package equipment control panel enclosures unless they also contain Class 1 starters.
7. Exterior Requirements
 - f. Panel shall be mounted in a secure manner to either a free standing metal frame or to a building wall. Panels shall not be secured to any equipment, ductwork or fan housings. Panels shall be mounted level.
 - g. Install a minimum 4x4 inch wire trough with removable cover above each local control panel and controller enclosure, excluding terminal units.
 - h. All low voltage wiring shall be routed into the panel through separate conduits from 120 VAC control wiring
 - i. Do not provide keyed locks in secured areas or rooms. Provide keyed locks in unsecured locations.
 - j. Provide plastic, engraved labels on the panel cover identifying the system controlled and the node number of the system as a minimum. If any manual reset devices are located with a given control panel, a plastic, engraved label shall indicate the device is present within the panel.
8. Interior Requirements
 - a. Devices mounted within a panel shall be arranged in a neat and orderly fashion. The bottom edge of each device shall be level with the bottom of the panel. Where possible group similar devices together and align vertically and/or horizontally.
 - b. All devices mounted within a panel shall be DIN snap track mounted whenever possible.
 - c. All field wiring entering/leaving the panel shall be connected to terminal strips located within the panel. Direct connection of field wiring to panel devices shall not be accepted unless the panel device is equipped with removable modular plug-in terminal blocks. Each terminal strip and each terminal on the strip shall be numbered and refer to the control drawings or point schedule in accordance with article Identification of Hardware and Wiring as discussed in Part 3 of this specification.
 - d. All field wiring entering the panel shall be identified by the point name or number on a label secured to the conductor or cable in accordance with article Identification of Hardware and Wiring as discussed in Part 3 of this specification.
 - e. All wiring labels shall be machine made, thermal transfer white laminated tape with black text, 180dpi, up to ¼" height tape, industrial strength tape adhesive and equal to Brother PT label makers with TZS tape. Label all control panel devices and terminal strips. All wiring shall be routed through adequately sized wire ducts. All wire ducts shall be run vertical and horizontal only. Provide intermediate wire ducts to minimize the length of exposed wiring from the wire duct to the individual devices. Provide snap covers on wire ducts. Overfilled wire ducts that prevent the easy installation of covers shall be replaced with larger duct.
 - f. All 120 VAC wiring shall be routed separately and not within wire ducts containing low voltage control wiring.
 - g. Exposed wiring shall be no longer than four inches.
 - h. Diagonal wiring is not acceptable.

- i. Provide pilot relays for digital output to reduce inducted noise from external devices.
- j. All power supplies and control transformers shall be protected by an appropriated sized UL listed fuse. Provide two (2) spare fuses in each local control panel for each fuse type used within that panel. Fuse block assemblies shall be designated to allow the easy removal/replacement of the fuse.
- k. Each local control panel (excluding terminal units) shall be provided with a laptop computer utility outlet protected by a separate 2A (max.) fuse.
- l. All enclosures shall be furnished with an interior plan pocket. A copy of as-built information associated with the panel shall be included in the panel's pocket.
- m. All enclosures must be clean and free of metal shavings and other debris.

3.7 CONDUIT AND WIRE

A. Control System Wiring

1. General Requirements

- a. All conduit, wiring, accessories and wiring connections required for the installing of the BAS shall be provided by the BAS Contractor.
- b. All wiring shall comply with all local and national electric codes.
- c. All conduit installed in a neat workmanlike manner according to NEC and Division 16.
- d. Follow manufacturer's installation recommendations for all communicating cabling.
- d. Control power wiring from a circuit breaker shall be provided by the BAS Contractor to the digital controllers and local control panels. Label the source electric panel and circuit breaker designation on each digital controller enclosure and local panel. Label the circuit breakers at the source electric panel.
- e. The Contractor shall be responsible for all electrical installation required for a fully functional system and not shown on the electrical plans or required by the electrical specifications.
- f. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers),
- g. Maximum allowable voltage for control wiring shall be 120V. If only higher voltages are available, the Contractor shall provide step-down transformers
- h. The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams at the job site with terminations identified.
- i. Do not run BAS wiring in conduits installed by other trades unless expressed permission granted, in writing, by that Contractor and **VPTC Management Partners, LLC**.

2. Conduit Requirements

- a. All control power wiring, interlock wiring, communication network wiring and device wiring shall be installed in conduit.
- b. All 120 VAC control power and interlock wiring shall be installed in separate conduits from all low voltage wiring.
- c. Network wiring installed within tele/com closets does not require conduit.

- d. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum of (6") from high temperature equipment (e.g. steam pipes or flues).
 - e. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
3. **Minimum Conduit Sizes and Fill Requirements**
 - a. Control wiring conduit shall be ½" minimum.
 - b. Communication network wiring conduit shall be ½" minimum.
 - c. No conduit shall be filled with more than 40% wiring.
 - d. Install one pull string in each raceway (1") or larger.
 - e. Adhere to applicable building code requirements where raceways cross the building.
 4. **Support Methods**
 - a. Provide support by mechanically attaching wiring, conduit, troughs, trays or raceway to supporting surfaces of building structure only. Support from ceiling grid hangers, lighting fixtures, electrical conduit, ductwork, piping, duct and pipe hangers shall be prohibited.
 - b. Sleeve through concrete surfaces with one inch minimum sleeves extending four inches above and one inch below floor slabs. Install rated fire stop material in all sleeves.
 - c. Protective bushings shall be used to protect wiring from damage during pulling.
 - d. Flexible metal raceways and liquid-tight metal raceways shall not exceed (3') in length and shall be supported at each end. Flexible metal raceway less than ½" electrical trade size, shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.
 - e. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
 5. **Low Voltage and Class 2 Wiring Requirements**
 - a. All Class 2 wiring shall be installed in conduit except above accessible ceilings and below accessible floors when allowed by local code.
 - b. Class 2 wiring not installed in conduit shall be supported and installed in accordance with local code required.
 - c. Low voltage control wiring shields shall be installed in separate conduits from 120VAC power wiring.
 - d. Low voltage wiring shields shall be terminated only at the control panel end. Tape all shields back.
 - e. Splicing of low voltage control wiring and network communication wiring is not permitted.
 - f. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.
 6. **Communication Wiring Requirements**
 - a. The Contractor shall adhere to the items listed in Wiring as mentioned in Part 3 of this specification, including requirements that all wiring be run in conduit.

- b. The Contractor shall adhere to the items listed in Wiring as mentioned in Part 3 of this specification, including requirements that all wiring be run in conduit.
- c. Do not install communication wiring in raceways and enclosures containing Class 1 wiring. The exception to this are control panels where the layout of the control panels shall be such that communication wiring does not have to cross any Class 1 wiring
- d. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
- e. Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable. Submit testing procedures in accordance with Submittals as described in Part 1 of this specification.
- f. When a cable enters or exits a building, a lightning arrestor must be installed between the two lines and ground. The lightning arrestor shall be installed according to the manufacturer's requirements.
- g. All communication wiring shall be labeled to indicate the origination and destination data.
- h. Grounding or coaxial cable shall be in accordance with NEC regulation article on "Communications Circuits, Cable, and Protector Grounding".

7. Minimum Wire Size and Type

- a. All system analog input wiring shall be jacketed twisted shielded pair, minimum 18 gage wire.
- b. All system analog output wiring shall be jacketed twisted shielded pair, minimum 18 gage wire.
- c. All system digital input wiring shall be jacketed twisted pair, minimum 18 gage wire.
- d. All system digital output wiring shall be jacketed twisted pair, minimum 18 gage wire.
- e. All low voltage 24VAC power wiring shall be jacketed twisted pair minimum 18 gage wire or larger and conform to local and national electrical codes.
- f. All internal panel device wiring for digital outputs and pilot relays shall be minimum 18 gage wire.
- g. All communication and network wiring shall be CAT5E / CAT6E.

8. Wiring Color Standards

- | | | |
|----|----------------------------------|--------|
| a. | 120 VAC instrument line power | Black |
| b. | 120 VAC instrument line neutral | White |
| c. | 120 VAC control signal | Red |
| d. | 24 VAC instrument line power | Brown |
| e. | 24 VAC instrument line neutral | Orange |
| f. | 24 VAC control signal | Yellow |
| g. | Grounds | Green |
| h. | Analog Input instrument signal | White |
| i. | Analog Output instrument signal | Blue |
| j. | Digital Input instrument signal | Black |
| k. | Digital Output instrument signal | Red |

3.8 INSTALLATION OF SENSORS

- A. Install sensors in accordance with manufacturer's recommendations.

- B. Mount sensors rigidly and adequately for the environment within which the sensor operates.
- C. Room temperature sensors installed in new walls shall be installed on concealed junction boxes properly supported by wall framing.
 - 1. Sensors in cafeterias, corridors, hallways, and other common areas shall have either stainless steel cover plate or appropriately sized plastic or metal wire, locking guard.
 - 2. Locate sensors such that computers, water coolers, and other heat generating equipment are not operating near a sensor.
 - 3. If terminal equipment is designated for future use, provide the sensor and 40' of wire coiled at the units.
- D. All wiring attached to the sensors in adverse areas shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
- E. Sensors used in mixing plenums and hot and cold decks, or duct over 48" shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the duct. Each bend shall be supported with a capillary clip. Provide 1 Ft of sensing element for each 1 Ft² of coil area.
- G. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat conducting fluid in thermal wells.
- H. Install outdoor air-temperature and humidity sensors on the north wall in aspirated enclosure at designated locations. If a location is not noted on the drawings, the submit location as part of submittals. See Part 1 of this specification.
- I. Differential air static pressure.
 - 1. Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pilot tube. Pipe the low-pressure port to a tee in the high pressure tap tubing of the corresponding building static pressure sensor (if available) or to the location of the duct high – pressure tap and leave open to the plenum. For VAV system applications, locate the high-pressure tap 2/3 of the way down the supply duct stream.
 - 2. Return Duct Static Pressure: Pipe the high-pressure tap to the duct using a pilot tube. Pipe the low-pressure port to the tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
 - 4. Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator and provide Air Monitoring's OA reference fitting or equal. Pipe the high-pressure port to an appropriate location in the space. Use Air Monitor's ceiling static fitting or equal.
 - 4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
 - 5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on the ductwork. Mount transducers in a location accessible for service without use a ladder or special equipment.
 - 6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

7. Provide accessories as required to dampen input signal to transducers and reduce fluctuations in the signal.
- J. Low-limit sensors and other safeties shall have at least two poles; one hard wired to fan starter, and one wired to the BAS. Low limit sensors will have an additional pole to interrupt power to the associated unit heating valves and economizer dampers.

3.9 ACTUATORS

- A. Mount and link control damper actuators according to the manufacturer's instruction.
 1. To compress seals when spring-return actuators are used on normally closed dampers, power actuators to approximately 5° open position, manually close the damper, and then tighten the linkage.
 2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
 3. Provide all mounting hardware and linkages for actuator installation.
- B. Electric/Electronic
 1. Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.
 2. Valves: Actuators shall be connected to valves by the manufacturer. New valves that require field mounting of actuator will not be accepted. Valves schedule designates the control panel to which the valve actuator is to be terminated.

3.10 INTEGRATION WITH THIRD-PARTY MANUFACTURER EQUIPMENT

- A. Provide interfaces to the following in accordance with Part 2 of this specification:
 1. Variable Frequency Drives
 2. Humidifier
 3. Chillers
 4. Boilers
 5. Rooftop Units
 6. Generator controller
 7. Electrical system controller
 8. Lighting control panels
 9. Liebert Computer Room Units
 10. UPS Systems
 11. Other devices per project requirements
- B. Provide hardwire interfaces to the following:
 1. Contact terminals for connecting by contractor supplying fire suppression system, ejector pump controllers and other devices per project requirements.
- C. Third party manufacturers shall provide LON interface. If the equipment does not have a LON interface available, BacNet or ModBus will be acceptable. Interface via Tridium Jace.

3.11 WARNING LABELS

- A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the BAS system.
 1. Labels shall use white lettering (12-point type or larger) on a red background.
 2. Warning labels shall read as follows:
C A U T I O N

This equipment is operating under automatic control
and may start or stop at any time without warning.
Switch disconnect to “Off” position before serving.

- B. Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
 - 1. Labels shall use white lettering (12-point type or larger) on a red background.
 - 2. Warning labels shall read as follows:
C A U T I O N
This equipment is fed from more than one
power source with separate disconnects.
Disconnect all power sources before serving

3.12 IDENTIFICATION OF HARDWARE AND WIRING

- A. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2” of termination with the BAS address or termination number.
- B. Permanently label for each point with code of field terminal strips to show the instrument or item serviced.
- C. Identify control panels with minimum ½” letters on engraved plastic nameplates. Nameplate shall include system controlled and node number of controller contained within the panel.
- D. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.
- E. Identify room sensors relating to the terminal box or valves with nameplates. For stainless steel cover plate sensors, identifier shall be on inside of plate.
- F. Manufacturer’s nameplates and UL or CSA labels are to be visible and legible after equipment is installed.
- G. Identifiers shall match record documents.

3.13 OPERATOR INTERFACE

- A. Provide the following user interface equipment and devices in accordance with Part 2 of the specification:
 - 1. One building workstation.
 - 2. One portable operator terminal.
 - 3. One hand-held interface tools
- B. The following graphic displays are required as a minimum. VPTC Management Partners, LLC shall provide contractor a graphic standard that will include the alarm page(s), “front page”, navigation “tree” and utility graphic. All other graphics shall be custom to the site and displayed per the VPTC Management Partners, LLC standard navigation “tree”.
 - 1. Building riser and/or floor plan to select major equipment
 - 2. Building floor plans that display all space temperature and allow the user to “click” on a temperature and view a detail graphic that shows each zone’s complete information.
 - 3. Schematic of each major HVAC system, heat pump water system, etc. including all setpoint changes and overrides.
 - 4. Historical display of trended data in both text based and graphical form.
 - 5. Alarm screen that allows acknowledgement

6. Schedule screens (Calendar & Occupied/Un-occupied)
 7. Utility and management screens.
- C. The following reports are required as a minimum. All reports are to be set up by the contractor installing the BAS and automatically downloaded with the frequency listed. As part of the training, demonstrate to **VPTC Management Partners, LLC** the process of creating these reports.
1. Measurement and verification report on a monthly basis including the following:
 - a. Utility and energy management information including measured data, input data and predicted data.
 - b. Equipment runtimes
 - c. Lighting control runtimes
 - d. Average space temperature
 - e. Average outside air temperature
 - f. Heating degree days
 - g. Wet bulb cooling degree days
 - h. Schedule hours of operation
 2. Predictive maintenance alarm log on a monthly basis
 3. VAV box report on a monthly basis including:
 - a. Average occupied space temperature
 - b. Average occupied airflow
 - c. Average occupied discharge air temperature
- D. Graphical User Interface screens will follow **VPTC Management Partners, LLC** standards and quality. For some example drawings, see Appendix “A” at the end of this specification section.

3.14 CONTROLLERS

- A. All control associated with a single AHU, DX condensing units, or other system, shall be on a single controller. The exceptions to this are global points such as outside air temperature.
- B. Provide the following spare point types and quantity on either an NAC or an SLC as follow.
1. Analog Input (AI) – (4) per mechanical room
 2. Analog Output (AO) – 2 per mechanical room
 3. Digital Input (DI) – (4) per mechanical room
 4. Digital Output (DO) – (4) per mechanical room
 5. It is the intent of this requirement that space capacity be distributed in the same fashion as connected points installed under the contract. Providing all spare points in one or two locations, if there are three or more locations of distributed I/O will not be acceptable.
 6. Provide spare capacity at the NACs for future terminal unit integration based on the following:
 - a. If all perimeter terminal VAV units have been installed and integrated with the shell building, provide 50% capacity (based on Number of ASCs provided with the shell project) for future ASC integration.
 - b. If all perimeter and interior terminal VAV units have been installed and integrated with the shell building, provide 10% capacity (based on number of ASCs provided with the shell project) for future ASC integration.
 - c. If all perimeter and interior terminal heat pump units have been installed and integrated with the shell building, provide 10% capacity (based on number of ASCs provided with the shell project) for future ASC integration.

- d. If only temporary heating minimum terminal VAV or heat pump units have been installed and integrated with the shell building, provide one point for each 1,000 net rentable square foot for future ASC integration.
- C. Provide network level controllers for this project as shown on the BAS drawings. If the capacity of the NAC require more than the minimum, then provide as many as needed to satisfy the point requirements of this specification.
1. Power line filtering: Provide transient voltage and surge suppression for all workstations and controllers. If surge protection is not provided integral to the NAC, then the Contractor will provide any wire or devices required to provide surge protection externally. Surge protection shall have the following as a minimum:
 - a. Dielectric strength of 1000V minimum
 - b. Response time of 10 nano seconds or less
 - c. Transverse mode noise attenuation of 65 dB or greater
 - d. Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz
- D. Power all temperature control panels from a dedicated power circuit.
1. Tag breaker in panels as “essential power, do not turn off”. All wiring by contractor.
 2. If emergency power is available in the building, then circuits for workstations, web server, primary NAC, and NAC/SLC/ASCs which control equipment connected to emergency power, shall be connected to emergency power panels.
- E. The NAC’s and SLC’s shall be powered from electrical circuits as shown on the electrical drawings, and they shall have a UPS that provides ½ hour operation on the processor components in the event of power failure.
1. Controllers on UPS shall include those for chillers, boilers, pumps, AHU’s.
 2. ASC’s need not be on UPS power
 3. Include UPS for BAS server/workstation if provided with the project

3.15 START-UP AND COMMISSIONING

- A. The Contractor shall coordinate with the Commissioning Authority regarding start-up and commissioning of the BAS and related equipment. As a minimum, the Contractor shall provide the items listed below.
- B. The Contractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and Sequence of Operations submitted. This work shall be completed prior to notifying **VPTC Management Partners, LLC** that the system is ready for acceptance.
- C. The Contractor is to take primary responsibility of start-up of all equipment and coordinate with other contractors and equipment manufacturers as necessary. The Contractor shall provide all labor and necessary test apparatus required to calibrate and prepare for service all of the instruments, controls and accessory equipment furnished under this specification.
- D. The BAS contractor shall test all control wiring and devices prior to start-up. This includes verifying that all wiring is properly connected and free of all shorts and ground faults. Verify that all connections are tightened appropriately. Calibrate each device as required by the manufacturer’s recommendations.
- E. Verify that the digital output devices operate properly and that the normal positions are correct.

- F. Verify that all analog output devices are functional, that start point and span are correct, and that direction and normal positions are correct including fail-safe positions. The Contractor shall check all control valves and automatic dampers to ensure proper action and closure. The Contractor shall make any necessary adjustment to valve stem and damper blade travel.
- G. Complete software shall be installed and tested (dry run) prior to start-up.
- H. Coordinate with Test and Balance:
 - 1. Provide training for the Test and Balance contractor on the tools needed to balance all VAV boxes.
 - 2. Provide software and field labor to correct BAS errors found during balancing.
 - 3. The balancer shall be able to perform the following tests through a portable interface provide by the BAS contractor. If a portable interface cannot be provided, then the BAS shall provide a technician to work with the balancer to accomplish the tests.
 - a. Set individual box to minimum CFM
 - b. Set individual box to maximum CFM
 - c. Set multiple boxes to maximum CFM simultaneously
- I. Software technician shall be on premise for all cut-overs, and remain “on call” for following 48 hours after any start-up. If called after normal hours, must respond within 4 hours, the premium portion only, of any call may be billed to **VPTC Management Partners, LLC**
- J. Software technician shall observe and fine tune all control loops.
- K. Alarms and interlocks:
 - 1. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - 2. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
 - 3. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
- L. Return the system to a normal operating state after each phase of start-up, commissioning and demonstration. Any points overridden, devices place in manual position, setpoint adjusted, etc. are to be restored to normal operation condition prior to acceptance.
- M. Connecting to the Internet must be tested and communication confirmed.

3.16 DEMONSTRATION

- A. The contractor shall fully comply with its responsibilities for demonstration of the BAS and related equipment.
- B. Items to be demonstrated to **VPTC Management Partners, LLC** will be defined by **VPTC Management Partners, LLC**. They may include, but are not limited to the following items:
 - 1. Actual field operation of each control and sensing point for all modes of operation including day, night, occupied, un-occupied, fire/smoke alarm, seasonal changeover, and power failure mode.
 - 2. Compliance with System Performance section of Part 1 of this specification.
 - 3. Compliance with Sequence of Operation of Part 4 of this specification.

4. Complete operation of operator interface.
 5. Optimal start, morning cool-down, morning warming-up, and un-occupied control modes.
- C. Any test that fails to demonstrate the operation of the system shall be repeated at a later date. The Contractor shall be responsible for the hardware and software necessary to complete all tests.
- D. Contractor shall remove and replace, at their expense, all items which are not in compliance with the specification requirements.

3.17 CLEANING

- A. The Contractor shall clean up all debris resulting from his/her activities daily. The Contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
- B. At the completion of work in any area, the Contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, debris, etc.
- C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material repainted to match the adjacent areas, at no cost for **VPTC Management Partners, LLC**

3.18 TRAINING

- A. Provide a minimum of four (4) on-site or classroom training sessions throughout the contract period for personnel designated by **VPTC Management Partners, LLC.**
- B. Provide two additional training sections at 6 and 12 months following the system acceptance and building turnover. Each section shall be two days in length and must be coordinated with **VPTC Management Partners, LLC.**
- C. Train the designated **VPTC Management Partners, LLC's** staff of representative to enable them to do the following:
1. Day-to-day Operations:
 - e. Proficiently operate the system
 - f. Understand control system architecture and configuration
 - g. Understand BAS system components
 - h. Understand system operation, including BAS system control and optimizing routines (algorithms)
 - i. Operate the workstation and peripherals
 - j. Log on and off the system
 - k. Access graphics, point reports, and logs
 - l. Adjust and change system setpoints, time schedule, and holiday schedules
 - m. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals.
 - n. Understand system drawings and Operation and Maintenance Manuals
 - o. Understand job layout and location of control components
 - p. Access data from BAS controllers and application specific controllers
 - q. Operate portable operator terminals.
 3. Advanced Operators

- a. Make and change graphics on the workstation
 - b. Create, delete, and modify alarms, including annunciation and routing of these
 - c. Create, delete, and modify point trend logs and graphic or print these both on an ad-hoc basis and at user-definable intervals
 - d. Create, delete, and modify reports
 - e. Perform BAS system field checkout procedures
 - f. Perform BAS controller unit operation and maintenance procedures
 - g. Perform workstation and peripheral operation and maintenance procedures.
 - h. Perform BAS diagnostic procedures
 - i. Configure hardware including PC boards, switches, communication, and I/O points
 - j. Adjust, calibrate, and replace system components
4. System Managers/Administrators
 - a. Interface with job-specific, third party operator software
 - b. Add new users and understand password procedures
- D. These objectives will be divided in three logical groupings. Participants may attend one or more of these, depending on level of knowledge required.
1. Day-to-day operators
 2. Advanced Operators
 3. System Managers/Administrators
- E. Provide course outline and materials in accordance with the Submittals section of Part 1 of this specification.
- F. The instructor(s) shall be factory-trained instructors experienced in presenting this material.
- G. Classroom training (limited to the first two sessions) shall be done using a network of working controllers representative of the installed hardware. Training just prior to and after the demonstration of the system shall take place on the installed system hardware and software components.
- H. Provide course outline and materials in accordance with the Submittals section of Part 1 of this specification. The instructor(s) shall provide one copy of training manual per student.

PART 4 – SEQUENCE OF OPERATION

4.1 SCOPE OF WORK

- A. Provide fully implemented application and custom software and controls necessary to accomplish the control sequences as part of this specification.
 1. The BAS system shall continuously monitor both outdoor and indoor conditions. It operates the HVAC equipment for the building and display/logs non critical alarms and broadcast critical alarms to the web supervisor.
 2. In addition to controlling HVAC systems, there is also integration and control of certain electrical, plumbing, and fire protection systems. Make special note of paragraph titled "Predictive Maintenance/Measurement and Verification" in this section.
 3. This sequence of operation may require minor changes or fine-tuning in the field to achieve **VPTC Management Partners, LLC's** exact operational requirements.

This Contractor will be responsible to coordinate with VPTC Management Partners, LLC and make the necessary software adjustments to achieve the intended results.

4. All setpoint values listed in this sequence or provided under custom or project specific sequences are operator adjustable unless noted otherwise. Any adjustable value must be adjustable from a graphic screen. Setpoints that are adjusted through database management, controller configuration screens or other similar manner will not be acceptable.
- B. The following sequences are designed to describe the scope of control required. The Contractor is responsible to expand these sequences in complete detail, describing all modes of operation, including, alarm conditions, failure modes, start-up, shut-down, etc. Submitted sequences are expected detailed, showing algorithms, and all “decision trees”.

4.2 GENERAL SEQUENCES

- A. The following sequences apply to each piece of equipment where applicable. When they are referenced in a specific sequence by name, they are considered to be included in their entirety. Note: All setpoints shown are to be operator adjustable from the graphic interface portion of the operator workstation.
- B. Economizer Flag:
1. The economizer flag will be ON if the outdoor air conditions are of a temperature with low humidity as based on the following conditions. All the conditions must be true:
OAT-DB is <76 °F
OAT-enthalpy is <32
OA absolute humidity ratio (OAAHR) is <0.013
 2. The flag will also be ON if the OAT-DB is less than 55 °F, regardless of humidity conditions
- C. Summer / Winter Operation: System will switch seasonal mode based upon an adjustable outside air temperature setpoint. Systems will not be able to switch from one mode to another unless the outside air temperature passes the setpoint by a pre-determined value for a set amount of time.
- D. Time of Day Schedule: Equipment that runs off a time of day schedule will have two, user definable schedules per day for each day of the week. In addition, the scheduling shall allow for up to 25 holidays and at least ten special-event schedules for each piece of equipment. In addition, the operator will have the ability to designate the last 0-2 hours of any occupied period as a coast time during which all space setpoints will be increased (or decreased based on the season) by a single, user-definable amount. Each terminal unit (VAV, heat pump, etc) shall have the ability to have an individual time schedule but shall also be able to be grouped with other terminal units for tenant or floor specific time schedules.
- E. Status Monitoring: All equipment that has status points will generate an alarm whenever the active state differs from the desired state. In addition, track run times for all such equipment based upon the equipment status. For variable frequency drives, monitor the VFD feedback and alarm points, as well as providing a separate current switch to monitor the fan status. Communication failures will also generate an alarm condition.
- F. Lead/Lag Control: Where equipment is staged in lead/lag fashion, set the lead equipment at a schedule time such that one piece of equipment will be lead for two weeks, and the other piece for one week. If status indicates that the piece of equipment is off, then generate an alarm and start the piece of equipment with the least run time.

Continue this staging as noted in this specific sequence of operation. When disabling lead/lag equipment, the equipment that came on last will be the first equipment to be disabled.

- G. Thermal Comfort Temperature Alarming: Space temperature and discharge air setpoints are set to maximize energy efficiency in accordance with ASHRAE Standard 90.1 and thermal comfort in accordance with ASHRAE Standard 55. If there is instability in any of the space and discharge air temperatures, either in the variance of the controlled variable from setpoint or in the change of the variable over time, then generate an alarm. The space temperature values may not vary by more than 1 °F from setpoint, or change by more than 1 °F per hour.
- H. Emergency Power: During emergency power, certain HVAC sequences will be altered, including limited chiller plant and AHU capacity and setpoint load-shedding on units. See individual equipment sequences for details.
- I. Alarm Notification: In addition to notification of alarms at the workstation, some alarms will be sent, via text message, to a text message pager or cell phone capable of accepting text messages. **VPTC Management Partners, LLC** will provide the pager or cell phone. Coordinate with owner and commissioning agent to determine which alarms will be sent via text messaging.

4.3 SEQUENCE OF OPERATIONS: The sequences and points in this section are regarded as a minimum. Whenever possible, LonMark ASC standards and manufacturer specific sequences shall be utilized. Project and application specific custom sequences are acceptable but must be pre-approved by **VPTC Management Partners, LLC** in advance.

A. Packaged (air cooled) Variable Air Volume (VAV) Air Handling Units: (RTU VAV system)

1. The RTU is a variable air volume (VAV) system consisting of a supply fan with a variable frequency speed drive (VFD), a direct expansion (DX) cooling coil, a full MODULATING gas burner or staged electric heating to maintain supply air tempering, outside and return air dampers, and a modulating power exhaust system for building relief.

2. The unit is equipped with its own control package that provides complete temperature and flow control for the unit. The Building Automation System (BAS) provides supervisory monitoring and control of the unit via a communication interface card. This card is to be provided by the mechanical contractor. The acceptable protocol: LonMark. The BAS will be allowed to change adjustable set points via this interface. It does not however perform any direct temperature or flow control of the unit.

3. Other sequences custom to the project may be required to accommodate project specific applications, carbon dioxide control of the interior conditioned spaces, etc. As stated, a complete detailed sequence of operation shall be submitted for approval prior to project start.

4. The RTU is equipped with a communication interface will allow for the following data points of integration to the BAS:

a. Read Only Points

- Supply Air Temperature
- Return air temperature
- Supply Air Static Pressure
- Supply Fan Speed
- Outside Air Damper Position
- Number of Stages of DX Cooling On
- Number of Stages or Percent of Heat On
- Alarms (all individual)
- Other points as required for sequence of operation, proper operator interface, systems integration and system safety

b. Read/Write Points

- Occupancy State
- Supply Air Temperature Set-point
- Supply Air Static Pressure Set-point
- Building pressure
- Morning warm up termination set point

- Economizer Enable Set-point
 - Minimum O.A. set-point
 - Other points as required for sequence of operation, proper operator interface, systems integration and system safety
- c. Alarm Points
- RTU supply fan failure
 - RTU return fan failure (if applicable)
 - RTU compressor failure
 - ❖ Per each compressor
 - RTU Heat failure
 - RTU Dirty Filter
 - RTU low supply air temp
 - RTU high supply air temp
 - RTU low return air temp
 - RTU high mixed air temperature
 - RTU low zone temperature
 - RTU high zone temperature
5. Occupied Operation:
- a. During occupied time periods the BAS system sends a start signal to the unit. The unit's control package performs the following functions whenever it receives an occupied signal from the BAS system:
- Starts the unit's supply fan.
 - Opens the unit's outside air damper to its minimum position.
 - Operates the unit's outside and return air dampers, in sequence with the unit's DX cooling, to maintain the unit's supply air temperature at the controller's set-point including the use of economizer mode in applicable locations.
 - Varies the speed of the supply fan to maintain the unit's supply air static pressure at set-point. In most applications, the BAS shall be programmed to adjust the static pressure set point automatically based on the operating conditions of the VAV terminal units. If 90% of the terminal units are at minimum position then the static pressure will adjust downward by .01" WC each minute until the percent of dampers at minimum position begins to decrease or the system reaches $\frac{3}{4}$ " wc. When the system determines that the terminal units are beginning to open their dampers or the average space temperature begins to increase, the static pressure shall be increased

by .01" w.c. every minute until the dampers again to begin to close back down.

- A supply air temperature reset program will be implemented so that each unit can have the supply air DAT reset based on internal conditions and exterior conditions comparisons all with adjustable set points including min and max limits.
- Vary the speed of the unit's exhaust fan to maintain the pressure of the office area, relative to outdoors, at set-point. Interior to be set at .035" w.c. maximum (adj).
- Refer to the documentation furnished with the rooftop unit for additional information on how the control package furnished with the unit operates the unit's components during the occupied time period.
- If equipped with carbon dioxide monitoring per project scope, the unit will adjust the amount of OA based on carbon dioxide levels in the RA or based on distributed sensors located throughout the buildings finished areas. All carbon dioxide set points shall be adjustable and OA control shall be proportional. When system indexes to unoccupied, the carbon dioxide levels will dictate the need to continue to operate the RTU to purge the building until level fall below set point. If the purge function exceeds an adjustable time limit, the unit will log and alarm and index to unoccupied.

6. Warm-Up Operation:

- a. The unit will enter its warm-up mode of operation if the unit's return air temperature is below its warm-up set-point whenever the unit initially receives the occupied signal from the BAS system.
- b. This system shall be programmed with an optimal start function to ensure the RA temperature is 3 degrees (adj) above the units warm up set point by the occupancy start time.
- c. The unit's control package performs the following functions during its warm-up mode of operation:
 - Closes its outside air damper and opens its return air damper
 - Disables operation of its modulating power exhaust system
 - Disables operation of its DX cooling
 - Energizes its gas or electric heat
 - The speed of the unit's supply fan is varied to maintain the unit's supply air static pressure at set-point
 - The unit operates on 100% return air with its electric heater energized to provide warm supply air to the VAV boxes.

- Once indexed to its warm-up mode of operation the unit continues to operate in its warm-up mode until the unit's return air temperature rises 3°F (adj) above the unit's warm-up set-point.
7. Unoccupied Mode of Operation:
- a. During unoccupied time periods the BAS system sends a stop signal to the unit.
 - b. The unit remains off unless a predetermined adjustable quantity of the VAV box space temperature sensors on a particular unit sense that its space temperatures have risen above the BAS system's unoccupied cooling set point (85°F adj.).
 - c. If any VAV box space temperature rises above the BAS system's unoccupied cooling set-point, the BAS system sends an occupied signal to the unit. This causes the unit to start and operate in its occupied mode of operation.
 - d. Once the BAS system sends a start signal to the unit it keeps the unit running until all of the VAV box space temperatures are 3°F (adj) below the BAS system's unoccupied cooling set-point
- B. Packaged (Water cooled) Variable Air Volume (VAV) Air Handling Units with central plant: (packaged units that reside on each floor, the central plant consists of building loop pumps, boiler and sand filter.
- 1. The air handling unit is a variable air volume (VAV) system consisting of a supply fan with a variable frequency speed drive (VFD), a direct expansion (DX) cooling coil, condensing water coil, electric heat and return air dampers.
 - 2. The unit is equipped with its own control package that provides complete temperature and flow control for the unit. The Building Automation System (BAS) provides supervisory monitoring and control of the unit. The BAS does not perform any direct temperature or flow control of the unit.
 - 3. Other sequences custom to the project may be required to accommodate project specific applications, carbon dioxide control of the interior conditioned spaces, etc. As stated, a complete detailed sequence of operation shall be submitted for approval prior to project start.
 - 4. The air handling unit is equipped with a communication interface that allows the air handling unit to communicate directly with the BAS. The following data points are integrated from the air handling unit controller to the BAS:
 - a. Read Only Points
 - Supply Air Temperature
 - Supply Air Static Pressure
 - Supply Fan Speed
 - Outside Air Damper/VAV Positions
 - Relief air damper position
 - Number of Stages of DX Cooling On
 - Number of Stages of Heat On

- Loop Pump Status
 - Loop Temperature
 - Cooling Tower sump temperature
 - Cooling Tower Fan status
 - Floor water alarm
 - Alarms
 - Other points as required for sequence of operation, proper operator interface, systems integration and system safety
- b. Read/Write Points
- Occupancy State
 - Supply Air Temperature Set-point
 - Supply Air Static Pressure Set-point
 - Condensing Water Loop Temperature Set-point
 - Economizer Enable Set-point
 - Loop pump command
 - Cooling tower command including control of VFDs if used
 - Cooling tower fan control
 - Condensing water loop pump commands (for all condensing water loop pumps (lead and lag)) including control of any VFD if used
 - Condenser water suction pressure
 - Alarm reset
 - Other points as required for sequence of operation, proper operator interface, systems integration and system safety
- c. Alarm Points
- Air handling unit supply fan failure
 - Air handling unit return fan failure
 - Air handler Remote condenser compressor failure
 - ❖ Per each compressor
 - Air handling unit low supply air temp
 - Air handling unit high supply air temp
 - Air handling unit low return air temp
 - Air handling unit high return air temp
 - Air handling unit low mixed air temperature
 - Air handling unit high mixed air temperature

- Air handling unit low zone temperature
 - Floor water sensor alarm
- d. The BAS system provides for time-of-day, day-of-week time scheduling of the unit. Based on the time-of-day and the day-of-week the BAS system will index the unit to occupied or unoccupied.
5. Occupied Operation:
- a. When scheduled to start normal operation, the unit's controls will enable the fan and the following functions the units shall be enable one by one with a 5 minute (adj) delay:
- Static pressure PID algorithms will "soft start" the frequency inverter and slowly ramp up to set-point.
 - A duct static pressure sensor through its controller shall modulate the fan's speed via a 4-20 mA signal to the fan speed controller to maintain its set-point.
 - If return air temperature is below morning warm-up (MWU) adjustable set-point, the outside air fan shall remain off and the outside air damper shall remain closed until MWU set-point is reached. Optimal start times shall be programmed so that the system ensure the MWU RA temperature is reached by the occupancy start time
 - Normal day operation will then enable the cooling control loop and open the O.A. damper, relief air damper, energize make up and relief fans as well as any other exhaust fans (toilet, etc), modulate OA VAV box to correct CFM for unit fan operation, etc.
 - A supply air temperature reset program will be implemented so that each unit can have the supply air DAT reset based on internal conditions and exterior conditions comparisons all with adjustable set points including min and max limits.
 - Mixed air low limit protection will protect the economizer coil from damage by stopping the fan, closing the outside air damper and opening the economizer coil valve.
 - An internal, adjustable fan "minimum-off" timer shall prevent cycling of the fan until a minimum off time has elapsed.
 - Refer to the documentation furnished with the unit for additional information on how the control package furnished with the unit operates the unit's components during the occupied time period.
- b. Warm-Up Operation:
- The unit will enter its warm-up mode of operation if the unit's return air temperature is below its adjustable warm-up set-point.

- The unit's control package performs the following functions during its warm-up mode of operation:
- Opens its return air damper
- Disables operation of its DX cooling
- Energizes its electric heat.
- The speed of the unit's supply fan is varied to maintain the unit's supply air static pressure at set-point
- The unit operates on 100% return air with its electric heater energized to provide warm supply air to the VAV boxes.
- Once indexed to its warm-up mode of operation the unit continues to operate in its warm-up mode until the unit's return air temperature rises 3°F (adj) above the unit's warm-up set-point.

5. Unoccupied Mode of Operation:

- a. The unit's controls will enter night setback mode (NSB) as scheduled by the central control system. The fan shall stop and the outside air damper and valves shall close.
- b. The unit remains off unless a predetermined adjustable quantity of the VAV box space temperature sensors sense that its space temperatures have risen above the BAS system's unoccupied cooling set-point (85°F adj.).
- c. If any adjustable quantity of VAV box space temperature sensors on the units zone falls below the BAS system's unoccupied adjustable cooling set-point, the BAS system sends an occupied signal to the unit. This causes the unit to start and operate in its occupied mode of operation all space temperature sensors on the units zone falls 3 degrees (adj) below the unoccupied cooling set point.

6. Condensing Water System Control Sequence

- a. On a start signal, the central control panel shall initiate the following sequence:
- b. The lead condenser water pump shall be energized and running.
- c. Pumps shall alternate lead-lag duty on an operator adjustable schedule. The standby pump shall remain off unless there is a failure of the lead pumps during the day. The standby shall energize on a lead pump failure and an alarm message shall be sent to the OWS.
- d. The cooling tower's control system shall be energized and the fans shall run according to the sequences outlined below.
- e. Upon proving condenser water flow through differential pressure type flow switches the self-contained units may start; subject to the time schedule.
- f. A temperature sensor with its sensing element in the condenser water suction piping at the cooling towers energizes the cooling

tower VFD and modulates the fan motor from low through high speed when the water temperature rises above 80 degrees (adj). If the tower is equipped with multiple fans, the second fan shall be energized when the first fan reaches 75% (adj) but the temperature is still not satisfied. The tower fan shall de-energize in a similar reverse sequence at a temperature of 2 degrees F. (adj) below their “start” setting.

- b. The system monitors the condenser water return pressure and if the pressure falls +/- 4 lbs (adj) below operating pressure, a critical alarm is sent. If the pressure continues to fall an additional +/- 2 lbs (adj), the lead and lag pumps are disabled.
 - c. Should the system see a loss of flow (adj time delay) on the closed loop or a supply water temperature of greater than 98 degrees (adj), the water cooled package unit compressors will be disabled to prevent compressor safety lock out.
 - d. The system shall monitor the phase loss control and disable all water cooled package units should a phase loss alarm be active. (Note, phase loss control module for all central three phase loads shall be a hard wire manual reset lockout.
 - g. The Waterside economizer shall be controlled by an outdoor air enthalpy sensor. Economizer cycle shall be energized at an outdoor air enthalpy of 20 BTU/LB (adjustable). The cooling tower fans shall be energized and all tower fans shall run when the basin water temperature is above 46 degrees F. (adjustable). For every degree (adjustable) blow 46 degrees F. one tower fan shall be de-energized. No tower fans shall run when the outside air enthalpy falls below 12 BTULB or the basin water temperature is less than 41 degrees F. (adjustable). The waterside economizer is de-energized when the outdoor air enthalpy rises above 20 BTU/LB (adjustable). The automatic changeover returns the system to its normal operation.
 - h. Upon failure of the tower fan, an alarm signal shall be sent to the OWS.
 - i. Time delays shall be provided in the motor starters to prevent tower fan motor damage.
 - j. On a stop signal, the central control panel shall initiate the following sequence:
 - k. Vertical self-contained units shall be de-energized.
 - l. Condenser water pumps shall be de-energized.
- D. Variable Air Volume (VAV) Terminal Units:
1. The variable air volume (VAV) boxes are indexed to occupied or unoccupied operation based on the occupied/unoccupied time period of the air handling unit which serves the boxes. Refer to the sequence of operation for the air handling units for information on what conditions determine their occupied/unoccupied time periods.
 - a. Read Only Points
 - Airflow
 - Discharge air temperature

- Damper position
 - Electric heat status
 - Other points as required for sequence of operation, proper operator interface, systems integration and system safety
- b. Read/Write Points
- Occupied and Unoccupied space temperature set-points
 - Heating dead band
 - Cooling dead band
 - Enable / Disable command
 - Maximum, minimum and heating CFM set points
 - Occupancy status/mode of operation
 - Space temperature
 - Other points as required for sequence of operation, proper operator interface, systems integration and system safety
2. Whenever the time period for an air handling unit is indexed to occupied, the controller for each box served by the unit is indexed to occupied.
 3. Each VAV box controller then operates its box to maintain the room's space temperature between its occupied cooling set-point and its occupied heating set-point.
 4. As the room temperature increases above the controller's occupied cooling set-point, the controller increases the amount of cool primary air to the space.
 5. If the room temperature decreases, the controller reduces the amount of cool primary air to the space.
 6. If the room temperature continues to decrease below the controller's occupied heating set-point, the controller operates the VAV box's electric or hot water coil as well as any baseboard heating incorporated with the box control to provide heat to the space.
 7. Whenever the time period for an air handling unit is indexed to unoccupied, the controller for each box served by the unit is indexed to unoccupied. Each VAV box controller then operates its box to maintain its space temperature at its unoccupied heating set-point.
 8. If the box's space temperature falls below its unoccupied heating set-point, the controller indexes its box to its heating CFM set-point and operates the box's reheat coil control valve.
 9. If the box is a fan powered van box and the space temperature falls below the occupied heating set-point, the controller indexes the fan to operate. If the space temperature does not rise above the set-point, the controller indexes the electric heat to be energized.
 10. If the box's space temperature is at its unoccupied heating set-point, the controller indexes its box to no flow from the unit.

11. An air handling unit delivers warm primary air to its VAV boxes when the unit operates in its warm-up mode of operation. When the unit is providing warm primary air to its boxes the VAV box controllers reverse the operation of their dampers.
 12. The VAV box controller reduces the amount of warm primary air if the room temperature rises above the controller's occupied cooling set-point.
 13. The VAV box controller increases the amount of warm primary air if the room temperature falls below the occupied heating set-point.
 14. If operator override space sensor control is selected as part of the project, the occupied heating set-point is equal to the set-point knob value minus 1°F, while the occupied cooling set-point is equal to the set-point knob value plus 1°F. This provides for a 2°F dead band between heating and cooling.
 15. The minimum allowable set-point for the set-point knob is 70°F (adj) while the maximum allowable cooling for the set-point knob is 78°F (adj). This provides for a range of 69°F to 77°F for the occupied heating set-point and 71°F to 79°F for the occupied cooling set-point. This function is programmed so that it can be enabled or disabled. If disabled, occupied set points are set and controlled through the system
 16. An unoccupied override push button on the face of the room temperature sensor permits the occupant to override the central unoccupied time period of an air handling unit. Whenever an override button is pressed the air handling unit is indexed to its occupied mode of operation for a time period of two hours.
 - a. Whenever one VAV boxes unoccupied override is pressed all the VAV boxes served by that air handling unit are indexed to occupy. This is done so a sufficient air flow path is provided for the air handling unit.
 - b. Once the two hour (adj) unoccupied override time period expires, the air handling unit returns to its mode of operation as determined by its time schedule.
 17. The VAV box unoccupied heating and cooling set-points are linked to the air handling unit's unoccupied heating and cooling set-points.
 - a. The VAV box unoccupied heating set-points are set 2°F higher than the air handling unit's unoccupied heating set-point, and their unoccupied cooling set-points are set at 2°F lower than the air handling unit's unoccupied cooling set-point.
- E. Fan Powered VAV Terminal Units with Heat: (many of the VAV functions above shall also apply to the fan powered boxes when applicable).
1. The units consist of a variable cold air volume damper, a constant volume discharge fan, and electric/hot water heating coil and pressure independent temperature controls.
 - a. Read Only Points
 - Airflow
 - Discharge air temperature
 - Damper position
 - Electric heat status/reheat coil valve position

- Fan status
 - Other points as required for sequence of operation, proper operator interface, systems integration and system safety
- b. Read/Write Points
- Occupied and Unoccupied space temperature set-points
 - Occupancy status/mode of operation
 - Heating dead band
 - Cooling dead band
 - Local temperature set point
 - Enable/Disable command
 - Max cooling set point
 - Min cooling set point
 - Min heating set point
 - Other points as required for sequence of operation, proper operator interface, systems integration and system safety
2. The terminal unit BAS controller shall be activated whenever the air handling unit serving the terminal unit is running.
3. The terminal unit fan shall operate whenever the unit is called to heat.
4. An analog temperature sensor sensing the space temperature and an airflow sensor sensing the cold air damper airflow volume shall provide inputs to the terminal unit BAS controller which shall modulate the cold air VAV damper, subject to scheduled minimum and maximum CFM limits (operator adjustable), and energized the fan and stages of the electric heater maintain the space temperature set point (operator adjustable).
5. Upon terminal unit shutdown, corresponding to shutdown of the air handling unit serving the terminal unit, the unit cold air VAV damper and hot water control valve shall close and the unit fan shall stop.
6. Terminal unit space temperature set point, zone temperature, minimum and maximum CFM set point and CFM flow shall be Operator addressable via BAS graphics with real time updates and operator reset of adjustable values.
- F. Building Ventilation (Outside Air), Relief and Central Toilet Exhaust Systems:
1. Building ventilation systems vary greatly so all sequences shall be project specific and presented to VPTC Management Partners, LLC for approval prior to project commencement.
 2. At a minimum, the BAS system shall monitor status of all exhaust/relief air fans, control each fan via time of day schedules and if equipped with VFDs, shall control the full range of operation based on design criteria.
 3. At a minimum, the BAS shall fully integrate into any package equipment designed to provide fresh air. All points relevant to the project shall be integrated and made available to the operator. At a minimum these shall

- include DAT, status (compressor, heating source), status, damper position, etc.
4. For make up air systems that provide air to the building via shafts to water cooled packaged units, the control of the fan, static, floor by floor dampers/VAV, etc will be integrated.
 5. Any ERVs provided with the project shall be integrated into the BAS and integration and sequence approved by VPTC Management Partners, LLC prior to project commencement.
- G. Elevator Penthouse Ventilation Control:
1. Provide controls necessary to maintain interior conditions within the manufacturer's recommendations. All sequences shall be based on unitary equipment provided with the project but shall minimally be fully integrated into a LonWorks controller.
- H. Fire and Smoke Damper Control:
- Where automatic fire and smoke dampers are provided, provide end devices and controls for damper closure indication. If so required, provide under this BAS contract. If the Fire Alarm vendor is providing under Division 16 scope, then the BAS Contractor shall just pick up necessary end switch points. If the fire and smoke dampers are exclusively controlled through the FA system, the BAS Contractor will provide static pressure safeties in each riser which has the ability to be completely isolated by the Fire / Smoke Dampers.
- a. Provide end switch on each damper zone and location.
 - End switch on 2-position 120 VAC is acceptable

4.4 Lighting Control

- A. The exterior accent lighting, parking lot lighting, parking deck lighting (where applicable), common area lighting (elevator lobbies, corridors, etc) and lobby area lighting shall be controlled through the BAS with an adjustable time schedule. Additionally, the BAS Contractor will provide a photo cell as a BAS point that can override the TOD schedule for the exterior lighting. All points associated with the lighting shall be adjustable and controlled through the NAC. The standard interface shall be via lighting contactor provided under Division 16, but based on project scope, integration shall be via a lighting control system and shall integrate to the BAS for complete control via open protocol.
- B. The BAS Contractor shall allow for at least two exterior lighting points.
- C. Parking decks will have ambient light sensors (ALS) installed at the perimeter so that the outer most banks of lights can be de-energized if the light levels are above an adjustable set point. These ALS's will be installed in sufficient enough quantities to allow for proper control of each elevation on each level. The ALS will also have a cloud cover time delay and be overridden by the TOD schedule when desired.
- D. Atriums will be equipped with ALS's and be subject to the same applicable requirements as above.
- E. The BAS Contractor shall allow for each elevator lobby and corridor lighting to be controlled.
 1. This contractor shall provide all low voltage control and wiring to operate the lobby and exterior accent lighting through the BAS system. This includes the wiring and terminations of low voltage wiring between the BAS system and the electrical lighting contactors. The only lighting control provided under this scope

of work is to control the lighting on the building schedule through the BAS. All contactor's lighting panels and line voltage wiring required to operate the lighting system shall be provided by the electrical contractor.

4.5 Building kWh Data

- A. Division 16 will provide a Siemens Model 9200 digital kW meter with the optional enhanced package 2 which shall allow for Modbus RTU communication to the NAC. This interface will allow for additional points electrical for integration into the BAS. The BAS contractor is responsible for the provision of integration:

Voltage (l-n) per phase	Voltage (l-l) per phase	Voltage (l-n) Avg.	Voltage (l-l) Avg.
Current per phase	Current Avg	Current Demand-Avg + per phase	Current Neutral
Energy (kWh) Imported	Energy (kWh)	Power (kW) Total	Peak Power demand (kw)
Frequency	Power Factor Total	Power (kW) per Phase	Power Factor per Phase
Reactive Energy (KVARH)	Apparent Energy	Reactive Power – per phase & total	Apparent Power –per phase & total
Reactive Power-Peak Demand	Apparent Power Peak Demand	THD Voltage & Current per Phase	

END OF SECTION 15950

Section 15990 - HVAC Operational Testing, Adjusting, and Balancing

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1 and Section 15010, "Basic Mechanical Requirements", govern this Section.

1.02 Description of Work:

- A. Work Included:
 - 1. All air and water systems shall be tested, adjusted, and balanced to optimize operating and comfort conditions. Record test data as outlined hereinafter and submit for review and approval. Systems shall be fully tested and balanced prior to Building Commissioning and acceptance.
 - 2. Conduct tests as specified herein, and as required by authorities having jurisdiction, including Local Inspection Department or Construction Manger.
 - 3. Repair or replace defects discovered or resulting from the required tests to a like new condition.

1.03 Quality Assurance:

- A. Testing and Balancing shall be performed by a testing agency who specializes in testing, adjusting, and balancing of heating, ventilating, air-moving equipment, air-conditioning systems and hydronic systems and has a minimum of one year experience.
- B. Testing agency shall be a certified member of Testing, Adjusting, and Balancing Bureau (TABB), Associated Air Balance Council (AABC), or National Environmental Balancing Bureau (NEEB).
- C. Qualification Statements: Submit company's certification documents including the following:
 - 1. Contractor Certification
 - 2. Supervisor Certification
 - 3. Technician Certification
- D. Testing agency shall have successfully completed a minimum of five projects, similar in size and scope.
- E. Testing agency shall be a third party company with no affiliation
- F. VPTC Management Partners, LLC reserves the right to require that the originally approved personnel be replaced with other qualified personnel if, in VPTC Management Partners, LLC's opinion, the original personnel are not qualified or are not properly conducting the system balancing.

Part 2 Products

2.01 Not Applicable

Part 3 Execution

3.01 Equipment Calibration:

- A. Instruments: Test instruments, devices, and similar items, their accuracy and the methods by which instruments are employed, shall be approved by VPTC Management Partners, LLC prior to use at the job site.
1. Submit evidence to show that the balancing devices are properly calibrated before proceeding with system balancing.

3.02 Preliminary Air Tests:

- A. General: Preliminary air tests shall be performed before duct work or equipment is enclosed in walls, floors, ceilings, chases, or in any other way concealed from view. Tests may be conducted on individual systems. Submit notification when systems are ready for preliminary air tests. Condenser water shall not be required for preliminary air tests. Make necessary arrangements to energize fan motors for the tests. Where possible, conduct the tests before the application of exterior duct insulation and installation of grilles or diffusers. Remove section of duct to allow design airflow at design static pressure where necessary.
- B. Tests: Demonstrate that there is no excessive leakage of the duct work by visual inspection, that fans are operating at essentially the correct speed, that motors will not overload, and that equipment delivers design cfm. Correct any deficiencies found. Repeat preliminary air tests until tests have proven satisfactory.

3.03 Examination:

- A. General: All equipment start-ups shall be complete, pipe cleaning and testing procedures completed, and systems are complete and ready for operation before final test and balancing of environmental system(s) is initiated.
- B. Prior to commencing testing adjusting and balancing, verify the following conditions, and if deficiencies are evident, submit deficiency report to VPTC Management Partners, LLC. Do not begin testing, adjusting, and balancing of environmental system until deficiencies have been remedied.
1. Systems are started and operating in a safe and normal condition.
 2. Control systems are installed, complete, and operable.
 3. Automatic and manual dampers are operable and fully open.
 4. Verify thermal overload protection is in place for fans, pumps, and other equipment and is properly sized for motor horsepower.

5. Verify that properly sized dual-element fuses, where specified, are installed in disconnect switches.
6. Start up air filters or filter media are removed and final filters are clean and properly installed. Balance system only with clean filters or filter media.
7. All screens are removed from air separators, suction diffusers, etc. and all strainers are clean.
8. Duct and fan systems are clean.
9. Fans are rotating correctly.
10. Fire and volume dampers are in place and open.
11. Air coil fins are cleaned and combed.
12. Access doors are closed and duct end caps are in place.
13. Air outlets are installed and connected.
14. Hydronic systems are pressure tested, flushed, filled, and properly vented.
15. Pumps are rotating correctly.
16. (Start-up/construction) strainers have been removed and all permanent strainers are clean and in place.
17. Gauges and/or test ports are properly located for balancing.
18. Service and balance valves are fully open.
19. Verify that expansion tanks have been pre-charged to correct operating pressure.
20. Check air vents at system high points and at water coils to ensure all air has been removed from the circulating systems

3.04 General Procedures:

- A. Recorded data shall represent actual measured or observed conditions.
- B. Permanently mark setting of valves, dampers, and other adjustment devices allowing for settings to be restored. Set and lock memory stops.
- C. Leave systems in proper working, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.05 Tolerances:

- A. Air Handling Systems: Adjust to within plus 10 percent of outlet total plus allowable leakage rate.
- B. Air Outlets and Inlets: Adjust total to within plus 5 percent or minus 5 percent of design for the space. Dampers in diffusers may be used for only 10% adjustment from full open airflow.

- C. Hydronic Systems: Adjust to within 10 percent of design flow.
- D. Hydronic terminal devices: Adjust to within plus or minus 10 percent of design flow.

3.06 Air Systems Procedure:

- A. Adhere to the follow procedures:
 - 1. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) HVAC Systems - Testing, Adjusting, and Balancing.
 - 2. AABC – National standards for total systems balance.
 - 3. NEBB – Procedural standards for test and balance of environmental systems.
 - 4. TABB – HVAC Testing, Adjusting, and Balancing International Standards
- B. Perform air systems testing and balancing on the following equipment:
 - 1. Packaged constant volume and variable volume rooftop units.
 - 2. Air handling units and indoor packaged systems.
 - 3. Fan-powered and standard VAV air terminal units.
 - 4. General exhaust and toilet exhaust systems.
 - 5. Building pressure relief dampers or systems.
 - 6. All air inlets and outlets.
- C. Minimum air procedures should include the following:
 - 1. Test and adjust fan RPM to design requirements.
 - 2. Test and record motor full load nameplate rating and actual ampere draw.
 - 3. Test and record system static pressures, fan suction, and discharge.
 - 4. Adjust all main supply and return air duct to within tolerances of proper design CFM.
 - 5. Test and adjust each diffuser, grille, and register. Reading and tests of diffusers, grilles, and registers shall include (design velocity (FPM)) and adjusted velocity, design CFM and adjusted CFM.
 - 6. Test and record outside, mixed air, and discharge temperatures (D.B. for heating cycle, D.B. and W.B. for cooling cycle).
 - 7. In coordination with the BAS contractor, set adjustments of automatically operated dampers to operate as specified, indicated and/or noted.
 - 8. Test and adjust air handling and distribution systems to provide required or design supply, return, outside, and exhaust air quantities within design tolerance.
 - 9. Make air velocity measurements in ducts by Pitot tube traverse entire cross sectional area of duct in accordance with SMACNA equal area method or Log Linear method.

10. Measure air quantities at all air inlets and outlets.
11. Use volume control devices to regulate air quantities only to the extent that adjustments do not create objectionable air motion or sound levels.
12. Vary total system air quantities by adjustment of fan speeds. Provide drive changes recommendations. Vary branch air quantities by damper regulation.
13. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for loading of filters and coils.
14. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions within specified tolerances.
15. Where modulating dampers or economizers are provided, take measurement at full return air, minimum outside air, and 100 percent outside air mode of operation.

3.07 Hydronic System Procedure:

- A. Adhere to the follow procedure:
 1. AABC – National standards for total systems balance.
 2. SMACNA – HVAC Testing, Adjusting, and Balancing International Standards
 3. NEBB – Procedural standards for TAB of environmental systems.
 4. Testing, Adjusting, and Balancing Bureau (TABB) - International Standards for Environmental Systems Balance
- B. Perform hydronic systems testing and balancing on the following systems and equipment:
 1. Cooling tower condenser flows and balance between cells, remote sumps, etc.
 2. Closed circuit fluid coolers flows and balance between cells, etc.
 3. Balance of heating hot water injection into building condenser water loop and setting of restrictor valves.
 4. Water-cooled chiller condenser and evaporator flows.
 5. Water-cooled data center conditioning unit flows.
 6. All air handling units and water-cooled packaged systems.
- C. Hydronic balancing shall include the following minimum data:
 1. Prepare itemized equipment schedules, listing all heating and cooling elements and equipment in the systems to be balanced. List in order on equipment schedules, by pump or zone according to the design, all heating and cooling elements, all zone balancing valves, and circuit pumps, ending with the last items of equipment or transfer element in the respective zone or circuit. Include on schedule sheet column titles listing the location, type of element or apparatus, design conditions, and measured conditions. Prepare individual pump report sheets for each zone or circuit.
 2. Adjust hydronic systems to provide plus or minus 10 percent of required design quantities.

3. Use calibrated Venturi tubes, orifices, metered fittings, pressure gages, and direct reading instrumentation to determine flow rates for system balance. Where flow-metering devices are not installed, flow balance on temperature difference across various heat transfer elements in the system is acceptable.
4. Adjust systems to provide specified pressure drops and flows through coils and heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
5. Effect system balance with automatic control valves fully open to heat or cooling transfer elements.
6. Adjust hydronic distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
7. Coil Temperature Readings: Set thermostat for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb temperatures at each cooling and heating coil or heat transfer element.
8. On multi-story buildings, record hydronic supply and temperatures at each floor level.
9. Test pumps and adjust flow. Record the following on pump report sheets:
 - a. suction and discharge pressure;
 - b. running amps and brake horsepower of pump motor under full flow and no flow conditions;
 - c. pressure drop across pump in feet of water and total GMP pump is handling under full flow conditions.
 - d. Permanently mark the balanced position for each valve.
10. On variable flow systems where available pump capacity is less than total flow requirements or individual system parts, proportional balancing must be performed.

3.08 Readjustment:

- A. General: During 6 months to one year after Final Acceptance, measure and, as necessary, adjust the rotative speed of each fan and blower whose performance is questioned by VPTC Management Partners, LLC.
- B. Tenant Finish: Subsequent to tenant finish layout, the Contractor responsible for tenant finish work shall balance each applicable system to the tenant design requirements. The building contractor shall clearly identify and describe any special balance requirements necessary to maintain the overall system balance.

3.09 Test Reporting:

- A. Test Forms: Record and submit test and balancing data on forms similar to those of the AABC, TABB or NEBB
- B. The air and water balance must be complete prior to the tenant or client taking possession of the space.

- C. A pencil copy of the air balance report is to be submitted to the owner prior the tenant or client taking possession.
- D. The final balance report is to be submitted no later than one week after the pencil copy has been submitted.
- E. Record test data after balancing has been completed and deliver recorded data to VPTC Management Partners, LLC for review and evaluation. Should deficiencies or discrepancies be found, repeat balancing procedures to achieve correct test data results. Certify the test and balancing data as being true and correct over the Contractor's signature. Execute the Certification by an authorized officer if the contracting firm is a corporation, by a partner if the firm is a partnership, by the firm's owner if the firm is a sole proprietorship, or by the authorized representative if the firm is a joint venture. Include a copy of the approved test and balancing data in the Owner's Manual.

END OF SECTION 15990

Section 15996- Interior Finish Mechanical Commissioning

Part 1 General

1.01 Related Documents:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", govern this section.

1.02 Definitions:

- A. Commissioning: The process and methods used to confirm that the design meets project criteria, the systems installed are fully functional, owner training is complete and record documentation has been provided to the owner.
- B. Commissioning Checklist: A summary of activities (tests) that are to be conducted by the installing contractor to verify and document that the equipment and systems are operational per the contract documents.
- C. Building Systems Performance Verification: A walk-through of the building systems conducted by VPTC Management Partners, LLC, with the installing contractor(s) where the contractor demonstrates the building equipment and system operation. During the demonstration VPTC Management Partners, LLC will evaluate the operation of the equipment and systems. All deficiencies noted during the demonstrations will be included on the commissioning punch list and distributed to the responsible contractor(s) for correction.

1.03 Description of Work:

- A. Purpose: To perform and document the testing required for the verification of the correct, or specified, operation of a system or piece of equipment.
- B. Work Included: The work includes, but is not limited to, the completion of the Pre-Commissioning Checklists as listed in this specification for the following equipment and or systems:

[EDIT FOLLOWING SECTION TO SUIT PROJECT]

15240	Vibration Isolation
15250	System Insulation
15440	Plumbing Fixtures and Trim
15675	Air Cooled Condensing Units
15680	Air Cooled Split System Air Conditioning Units
15786	Water Source Heat Pumps
15891	Ductwork
15910	Ductwork Accessories
15931	VAV and Fan Powered System Terminal Units
15950	Direct Digital Control System
15990	HVAC Operational Testing, Adjusting, and Balancing

[END OF SECTION TO BE EDITED]

1.04 Quality Assurance:

- A. The installing contractor shall complete the commissioning checklists during the construction of the project.
- B. Three (3) copies of the completed commissioning checklists and supporting documentation including piping pressure test reports, air balance reports and equipment start up reports shall be provided by the contractor. One (1) copy is to be provided to the on-site superintendent and (1) copy is to be submitted to the VPTC Management Partners, LLC project manager and (1) copy is to be inserted into the operations and maintenance manual.
- C. All commissioning checklists are to be completed in their entirety. Where requirements are not applicable to the specific scope of work, the checklists are to be marked accordingly. All checklists are to be signed by the individual or individuals completing the checklists.

Part 2 Execution

- A. The contractor shall have the responsibility of coordinating the completion of the commissioning checklists with other contractors as necessary.
- B. The commissioning checklists are to be completed at a time that will not impede the progress of other trade construction.
- C. The contractor shall provide all equipment and technical support required to complete the commissioning checklists.
- D. The sub-contractor shall include with the commissioning checklists the completed air balance reports, equipment start up reports, pressure test reports and hydrostatic test reports. All commissioning documentation is to be completed prior the tenant occupying the space.

Part 3 Commissioning Checklists

- A. Refer to the attached Commissioning Checklists included in this specification.

15996 Interior Finish Commissioning Checklist

#1	15010 – Basic Mechanical Requirements	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	The local inspecting authority has completed final inspections for mechanical systems and all systems passed.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#2	15010 – Basic Mechanical Requirements	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Record set of documents includes (3) sets of color-coded zoned drawings that reflect each terminal box or heat pump zone.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#3	15010 – Basic Mechanical Requirements	<input type="checkbox"/> Complete	Punchlist Requirement	Status

	All warranty documentation has been provided to VPTC Management Partners, LLC.	<input type="checkbox"/> Punchlist <input type="checkbox"/> N/A		
#4	15010 – Basic Mechanical Requirements	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	All training and owner demonstration has been completed.	<input type="checkbox"/> Punchlist <input type="checkbox"/> N/A		
#5	15010 – Basic Mechanical Requirements	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Where requested and/or applicable to the project, owner’s manuals have been submitted to VPTC Management Partners, LLC.	<input type="checkbox"/> Punchlist <input type="checkbox"/> N/A		
#6	15010 – Basic Mechanical Requirements	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	All commissioning documentation has been completed and 2 copies provided to the VPTC Management Partners, LLC superintendent or project manager.	<input type="checkbox"/> Punchlist <input type="checkbox"/> N/A		
#7	15240 – Vibration Isolation	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Isolation springs, rubber isolators and flexible connections have been properly installed.	<input type="checkbox"/> Punchlist <input type="checkbox"/> N/A		
#8	15250 – System Insulation	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Insulation is complete and the insulation materials installed have been kept clean and dry.	<input type="checkbox"/> Punchlist <input type="checkbox"/> N/A		
		<input type="checkbox"/> N/A		
#20	15440 – Plumbing Fixtures	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	All the plumbing fixtures operate correctly. Automatic and manual flush valves have been adjusted.	<input type="checkbox"/> Punchlist <input type="checkbox"/> N/A		
#21	15440 – Plumbing Fixtures	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Pressure regulating valves have been adjusted to maintain manufactures recommended water pressure to each restroom group on each floor.	<input type="checkbox"/> Punchlist <input type="checkbox"/> N/A		
#22	15440 Valves	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Valves have been provided at the hot water heater enabling the removal of the heater without interruption to the building domestic water service.	<input type="checkbox"/> Punchlist <input type="checkbox"/> N/A		

#23	15458 – Electric Water Heater	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	The domestic hot water temperature has been set per code.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#24	15458 – Electric Water Heater	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	A rupture pan has been provided and is piped to the mop sink or nearest floor drain.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#25	15510 – Mechanical Piping Systems	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	All piping installed has been adequately supported and no piping is supported by other piping, conduit or ductwork systems.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		

#46	15891 – Ductwork	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	The general condition of the ductwork is good; there are no dents, rust or other signs of discoloration.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#47	15891 – Ductwork	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Flexible ductwork connections have been made to air handlers, fans and similar equipment. The flexible ductwork connection is airtight.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#48	15891 – Ductwork	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	The ductwork hanger system has been installed where the ductwork is supported rigidly and the duct is held true to shape, there is no buckling of the ductwork.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#49	15891 - Ductwork	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Outside air distribution throughout the plenum space has not been interrupted by the construction of walls to the deck. Where walls have been constructed to the deck, dampers or the continuation of the ductwork have been provided to maintain code-required airflow to all areas of the tenant occupied spaces.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#50	15891 – Ductwork	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Flexible ductwork runs do not exceed eight feet.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#51	15891 – Ductwork	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Ductwork joints have been sealed to prevent leakage.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#52	15931 – VAV Terminal Boxes	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	For fan-powered boxes with electric heat, the supplemental heater does not operate without airflow.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#53	15931 – VAV Terminal Box	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	The thermostat installed for the box is local to the box, (not separated from the unit by walls) and the stat has been calibrated.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		

#54	15931 – VAV Terminal Box	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	The new or relocated unit has been programmed into the direct digital control system and will control in sequence with the existing system.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#55	15891 – Ductwork	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Verify that all offices have supply diffusers and return grilles.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#56	15931 – VAV Terminal Box	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	The vav or fan terminal unit is located in a position that is accessible and can be maintained. The box is adequately supported.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#57	15931 – VAV Terminal Box	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	The fan terminal box or vav does not produce objectionable noise in the space the box is serving.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#58	15950 – Direct Digital Controls	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	The graphics for the DDC system have been upgraded with the added equipment under the interior finish.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#59	15990 – Air Balance	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	A certified air balance report has been submitted to VPTC Management Partners, LLC. All equipment within the report is operating within 10% of design.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#60	15990 – Air Balance	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Outside air minimum requirements for all roof top equipment has been documented in the report.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#61	15990 – Air Balance	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	Prior the final air balance, clean filters have been installed on all air handling equipment. The filter replacement includes rooftop units, heat pumps, terminal boxes and split systems.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		
#62	15510 – Mechanical Piping Systems	<input type="checkbox"/> Complete	Punchlist Requirement	Status
	All piping installed has been adequately supported and no piping is supported by other piping, conduit or ductwork systems.	<input type="checkbox"/> Punchlist		
		<input type="checkbox"/> N/A		

END OF SECTION 15996 INTERIOR FINISH MECHANICAL COMMISSIONING