

SECTION 23 00 10 - MECHANICAL SCOPE OF WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. General: Provide labor, materials, tools, machinery, equipment, appliances, and services necessary to complete the specified mechanical work of this Division. Coordinate Work with other trades to prevent conflicts without impeding job progress.
- B. **[Project Schedule/Milestones: The scope of the project will require certain construction work to be completed by intermediate milestone dates. Refer to Division 1 for additional information on project schedule and milestone dates.]**
- C. Utility Charges: The Contractor shall pay fees, tap charges, meter charges, and special fees assessed by the local utilities or local authorities.
- D. Work Included: The Work includes, but is not limited to, the following systems, equipment, and services:

[EDIT TO SUIT PROJECT]

- 1. **[A Complete] [Modification] [An Extension]** of the **[Campus] [Building]** Chilled Water Cooling System including, but not limited to:
 - a. **[Centrifugal] [Reciprocating] [Air-cooled]** water chilling units.
 - b. Chilled water pumps.
 - c. Chilled water piping and coils.
 - d. Insulation, controls, accessories and chemical treatment.
 - e. Refrigerant leak detection.
 - f. Refrigerant purge exhaust system.
 - g. Additional items specified, indicated or implied on the Drawings.

[OR]

- 2. A complete Roof-Top Package Air Conditioning Systems Consisting of:
 - a. Manufacturer's roof curb.]
 - b. Refrigerant compressors, condenser fan motors and supply fan motors.]
 - c. Vibration isolation, refrigerant piping, drains and coils.]
 - d. Insulation, controls, accessories and filters.]
 - e. Additional items specified, indicated or implied on the Drawings.]
- 3. A complete Condenser Water System including, but not limited to:
 - a. Cooling towers.
 - b. Condenser water pumps.
 - c. Condenser water piping.
 - d. Controls, chemical treatment and accessories.
 - e. Insulation and accessories.
 - f. Additional items specified, indicated or implied on the Drawings.
- 4. **[A complete] [An Extension of the [Campus] [Building]** Steam System including, but not limited to:
 - a. Steam boilers.
 - b. Boiler feed deareators.

- c. Condensate return units.
 - d. Steam and condensate piping.
 - e. Pressure reducing valves, steam traps, pressure relief valves and steam accessories.
 - f. Additional items specified, indicated or implied on the drawings.
5. A complete Hot Water Heating System including, but not limited to:
- a. **[Hot water boilers] [Steam to hot water converters]**
 - b. Hot water piping.
 - c. Hot water heating coils.
 - d. Hot water pumps.
 - e. Controls, chemical treatment and accessories.
 - f. Insulation and vibration isolation.
 - g. Additional items specified, indicated or implied on the Drawings.
6. A complete Electric Heating System Including, but not limited to:
- a. Electric heaters in HVAC terminal units.
 - b. Electric duct heaters.
 - c. Controls.
 - d. Insulation and vibration isolation.
 - e. Additional items specified, indicated or implied on the Drawings.
7. Air Handling Units **[and Fan Coil Units]** including, but not limited to:
- a. Fan section with motor.
 - b. Chilled water cooling coils.
 - c. **[Hot water] [Electric]** heating coils.
 - d. Filters.
 - e. Controls **[and variable air volume modulation]**.
 - f. Vibration isolation, insulation and drains.
 - g. Additional items as specified, indicated or implied on the Drawings.
8. Energy Recovery System:
- a. Water Piping and Coils
 - b. Circulation pumps
 - c. Insulation, controls, accessories and chemical treatment
 - d. Filters
 - e. Motors
 - f. Additional items, indicated or implied on the drawings.
9. Complete Air Distribution Systems including, but not limited to:
- a. Sheet metal ductwork.
 - b. HVAC terminal units.
 - c. Fire, fire/smoke, and smoke dampers, balancing dampers and accessories.
 - d. Grilles, registers and ceiling outlets.
 - e. Insulation.
 - f. Acoustical treatment of ducts.
 - g. Sound attenuating equipment, lined elbows and transfer ducts.
 - h. Additional items as specified, indicated or implied on the Drawings.

[SELECT ONE OF THE FOLLOWING]

10. A complete Automatic Temperature Control System including, but not limited to:]

- a. Building Controls and Automation as specified and required including all the necessary controls, wiring and installation. System to be installed shall be as specified in this Division providing a complete system of pneumatic, electronic, and computer devices to perform the sequences and programs outlined herein.
- b. Pneumatic, electric, and electronic control for all equipment to provide the specified Sequence of Controls, and as specified hereinafter including thermostats, sensors, relays and motors.
- c. Pneumatic damper operators and control valves furnished to the appropriate trade as specified under the Work of other Sections.
- d. Control panels as specified hereinafter and as required.
- e. Complete instrument air system including air compressors and receivers, refrigerated air dryers, appropriate accessories and distribution piping.
- f. PC based central computer and associated peripherals and software as specified in the subsequent sections of this Division functioning as the primary operator interface for the BCAS. All hardware and software required for interface to the communications network and peripheral devices shall be included.
- g. Other miscellaneous control system and components as shown on the Drawings and/or specified herein.
- h. Additional items as shown on the Drawings as specified or required to provide the specified controls and sequences.

[OR]

11. **[A] [Provisions for a] complete Building Control and Automation System (BCAS) as [specified] [furnished] in Division 23. [Division 23 shall be included in the work of Division 23.]** Division 23 provisions for BCAS system installation shall include, but not be limited to:
 - a. Install immersion wells, pressure taps and any associated shut-off cocks.
 - b. Install flow switches.
 - c. Install automatic control valves.
 - d. Install level switches.
 - e. Furnish and install venturi flanges.
 - f. Install venturis and flow sensors.
 - g. Furnish automatic valve flanges and flange gaskets, increasers, reducers, nuts and bolts as required.
 - h. Furnish flare nuts for unitary valves.
 - i. Furnish union fittings where required in unitary equipment for service of automatic valves, including necessary transitions.
 - j. Install automatic control dampers.
 - k. Provide necessary transitions and blank-off plates required to install dampers that are different than duct size.
 - l. Assemble multiple section dampers with required interconnecting linkages and extend required number of shafts through duct for external mounting of damper motors.
 - m. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation and affix and seal permanently in place only after stratification problem has been eliminated.
 - n. Provide access doors or other approved means of access through ducts for service to control equipment.
 - o. Include necessary duct transitions to provide velocities as recommended by air flow measurement station manufacturers.
 - p. Install air flow measurement stations as indicated on the Drawing, specified or required.

- q. The centrifugal chillers furnished under Division 23 shall include all factory-furnished control devices, transformers, relays and other appurtenances as required per the chiller manufacturers wiring diagram. All wiring and pneumatic piping on the chiller shall be the responsibility of the chiller manufacturer. The control interface module for each chiller shall be furnished and factory-installed by the chiller manufacturer and shall accept a **[3 to 15 psi] [4-20 mA] [0-10 volts dc]** input.]
 - r. HVAC terminal units provided by Division 23 shall have velocity sensors, DDC controllers and damper actuators provided under Division 23, factory-installed and wired ready for field control connections by Division 23.
12. Complete Ventilating Systems including, but not limited to:
- a. Exhaust fans.
 - b. Supply fans.
 - c. Ductwork, grilles, air devices, dampers, controls and similar items.
 - d. Additional items specified, indicated or implied on the Drawings.
13. A complete CPU Chilled Water Cooling System including, but not limited to:
- a. Packaged **[glycol-cooled] [air-cooled]** CPU chillers.
 - b. Hose kits.]
 - c. Insulation, controls, accessories and chemical treatment.
 - d. Additional items specified, indicated or implied on the Drawings.
14. A complete Glycol Water System including, but not limited to:
- a. Dry coolers.
 - b. Primary and secondary glycol pumps.
 - c. Glycol piping.
 - d. Controls, chemical treatment, insulation and accessories.
 - e. Additional items specified, indicated or implied on the Drawings.
15. A complete **[Computer] [Telephone]** Room Air Conditioning System including, but not limited to:
- a. Packaged **[glycol-cooled] [chilled water] [air-cooled]** air conditioning units.
 - b. Floor stands.
 - c. **[Glycol] [Chilled water]** piping connections.
 - d. Controls, accessories and filters.
 - e. Additional items specified, indicated or implied on the Drawings.
16. A complete Plumbing System including, but not limited to:
- a. Plumbing fixtures and trim.
 - b. Domestic hot water supply piping.
 - c. Domestic cold water supply piping, including connections to the water service.
 - d. Domestic water heaters.
 - e. Electric drinking fountains.
 - f. Sanitary waste piping, including connection to sanitary sewer system.
 - g. Storm drain piping, including connection to storm sewer system.
 - h. Vent piping.
 - i. Domestic water pumps and controls.
 - j. Roof and floor drains.
 - k. Sewer and water main extensions.
 - l. House\break tank(s).
 - m. Water softeners.

- n. Insulation, controls, safety devices, vibration isolation and similar items.
 - o. Gas piping, including connection to local gas service.
 - p. Fuel oil tank(s), pumps, piping and controls.
 - q. **[Laboratory] [Medical] pumping systems.**
 - r. **[Laboratory] [Medical] gas delivery system.**
 - s. Additional items specified, indicated or implied on the Drawings.
17. A complete Fire Protection System including, but not limited to:
- a. Fire Department connections.
 - b. Fire pumps, jockey pumps and pump controllers.
 - c. **[Wet-pipe, dry-pipe, and pre-action]** automatic sprinkler systems.
 - d. Alarms and flow switches.
 - e. Standpipes and hose valves.
 - f. Connection to water mains.
 - g. House/break tank(s).
 - h. **[Clean Agent fire suppression systems.]**
 - i. Additional items specified, indicated, or implied on the Drawings.
18. Connections to equipment furnished by the General Contractor or other Divisions.
19. Connections for Owner-furnished equipment where shown on the Drawings or specified.
20. All water services.
21. All sewer services.
22. All water treatment.
23. Testing[,] **[and provisions for]** balancing and adjusting of mechanical systems as specified.
24. Additional items as shown on the Drawings or specified.
25. Structural Openings:

[EDIT TO SUIT PROJECT]

- a. **[The Mechanical Contractor shall cut or provide and locate all forms for holes through the roof for his equipment, provide counterflashing for all duct openings in roof and provide roof jackets or pitch pockets for pipe and conduit passing through the roof. Provide reinforcement of all holes through roof, where required, in a manner approved by the Structural Engineer.]**

[OR]

- b. **[The Mechanical Contractor shall be responsible for coordinating all required openings in new construction with the General Contractor and furnishing and locating forms where appropriate.]**
- c. **[The Mechanical Contractor shall provide the Structural Engineer with locations, dimensions, and weights of his equipment to be supported by the floor and roof structural systems immediately following the awarding of the Contract. The final locations of his equipment shall be subject to the approval of the Structural Engineer. The Mechanical Contractor shall provide accessories necessary to hang his equipment from structure at locations and in a manner approved by the Structural Engineer.]**

[or]

- d. **[The Mechanical Contractor shall be responsible for coordinating all required openings in existing construction with the General Contractor and [Landlord] [Owner] and shall be responsible for cutting or drilling required openings in a manner which is acceptable to the [Landlord] [Owner]. Cutting and drilling**

operations shall be performed at times which are acceptable to the [Landlord]
[Owner].]

- e. [Roof curbs and skids for mechanical equipment will be furnished by the Mechanical Contractor who shall locate, install, and provide the counterflashing. Factory curbs may be used pending approval of installation and location by the Structural Engineer.]
- f. [Except as otherwise indicated on the Drawings, all holes of area less than 150 square inches required through concrete floors, precast concrete, masonry, and similar items, shall be provided by the Mechanical Contractor. All holes required through post-tensioned concrete floors and roof and all other holes that proper mechanical installation require to be of a larger area than 150 square inches will be provided by the Contractor for precast construction at locations determined by this Contractor. Any cutting and patching for holes required for proper mechanical installation where information on sizes and locations is not provided to the Construction Manager in sufficient time shall be the responsibility of the Mechanical Contractor. All cutting and patching shall be subject to the direction and approval of the Architect.]

PART 2 - PRODUCTS

2.1 GENERAL:

- A. Refer to specific Sections of the Specifications for equipment.

PART 3 - EXECUTION

3.1 GENERAL:

- A. Installation shall be in accordance with the Specification section pertaining to the individual equipment.

END OF SECTION 23 00 10

SECTION 23 01 00 – MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. General: This Division requires the furnishing and installing of all items Specified herein, indicated on the Drawings or reasonably inferred as necessary for safe and proper operation; including every article, device or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the work include, but are not limited to, materials, labor, supervision, supplies, equipment, transportation, storage, utilities and all required permits and licenses. All work performed under this Section shall be in accordance with the Drawings and Specifications and subject to the terms and conditions of the Contract. For purposes of these Specifications, "provide" and "furnish and install" shall be synonymous. Owner's Representative (OR) shall refer to the individual designated by the owner to receive and distribute correspondence with the contractor.
- B. Work Included: This Work includes the furnishing of all labor, materials, equipment, fixtures, apparatus and appurtenances required for complete installation of operating heating, ventilating, air conditioning, plumbing and fire protection systems as specified, in place and ready for service. Refer to Section 23 00 10, "Mechanical Scope of Work" **[and Division 23]** for additional requirements.
- C. Drawings: Refer to the Mechanical and Plumbing Drawings for graphic representations, schedules, and notations showing mechanical and plumbing work.
- D. Specifications: Refer to this Division for the primary technical specifications of mechanical and plumbing work.
- E. Work of Other Sections: Requirements given within this Section apply to the Work of all Sections of this Division. The actual performance of the Work stays within the Section in which it occurs; but subject to the requirements of this Section to the extent applicable.

[EDIT TO SUIT PROJECT]

[COORDINATE REQUIRED PAINTING WITH ARCHITECT]

1. **[Finish painting of mechanical systems in areas exposed to the view of building occupants is specified in other Divisions.]** All prime[, finished] and protective painting for all areas **[and finished painting of mechanical systems in areas not exposed to the view of building occupants]** shall be provided under this Division.
2. Installation of electrical control power which is not specified as an integral part of equipment specified under this Division is specified under Division 26 and where shown on the Electrical Drawings. Necessary conduit, wiring, boxes, and fittings are specified under Division 26.
3. Access doors in finished surfaces are **[provided under this Division and installed by the Contractor installing the finished surface.] [specified under other Divisions]**. Locations are as shown on the Drawings and as required for proper equipment access. **[Access panels shall be located on coordination drawings provided by this contractor and based on final equipment locations and access requirements.]**
4. Concrete housekeeping pads and supporting structures are specified under **[other] [this] Division[s]. [Dimensions and locations of pads and supports shall be the responsibility of this Division.] [Housekeeping pads shall be located on coordination drawings provided by this contractor and based on actual equipment being furnished and final equipment locations.]**
5. Pits for sewage ejectors, storm water, and other pumps are specified in other Divisions. Dimensions and locations of pits shall be the responsibility of this Division.
6. Subsurface drainage up to and including pump pits is the responsibility of other Divisions.

7. Owner and General Contractor-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.
 8. Motors for all equipment shall be furnished and installed with the equipment furnished by this Contractor. Refer to Section 23 04 00, "Motors and Controllers", for additional information.
 9. 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 wiring and connections are included in the Work of Division 26. Refer to Section 23 04 00 for additional information.
 10. Standby engine-driven emergency generator exhaust piping shall be furnished, installed and insulated under this Division. Exhaust silencer(s), flexible exhaust connector(s), ventilated exhaust thimble(s) and condensation trap(s) shall be installed and insulated (as required) under this Division. The exhaust silencer(s), flexible exhaust connector(s), and ventilated thimble(s) shall be furnished by Division 26.
 11. Standby engine-driven emergency generator cooling supply and exhaust air ductwork and dampers shall be furnished and installed under this Division. Engine generator set-mounted closed-circuit radiator and engine-driven fan shall be furnished under Division 26.
 12. **[Building Controls and Automation are provided under Division 23. Refer to Section 23 00 10 for Division 23 interface requirements.]**
- F. Workmanship: All mechanical and plumbing work shall be constructed and finished in every respect in a workmanlike and substantial manner. Furnish and install all work as may be necessary to complete systems in accordance with the best trade practice and to the satisfaction of the OR and Engineer. The entire installation shall be ready in every respect for satisfactory and efficient operation when completed. The OR and Engineer will interpret the meaning of the drawings and specifications and will reject all work and materials which, in their judgment, is not in full accordance therewith.
- G. Certification: Submit a single certification stating that all portions of the work are in accordance with contract requirements. Warranty all work against faulty and improper material and workmanship for a period of one year from date of final acceptance by the OR, except that where guarantees or warranties for longer terms are specified by contract, such longer term shall apply. At no additional cost to Owner, within 24 hours after notification, correct any deficiencies which occur during the warranty period, to the satisfaction of the Owner.
- H. Safe Work Place: The Contractor covenants and agrees that he and his Subcontractors and his and their agents and employees will provide and maintain a safe place to work and will comply with all laws and regulations of any governmental authorities having jurisdiction thereof, and the contractor agrees to indemnify, defend and hold harmless, the Engineer and Owner from and against any liability, loss, damage or expense, including attorneys' fees, arising from a failure or alleged failure on the part of the contractor, his subcontractors and his and their agents and employees to provide and maintain a safe place to work or to comply with laws and regulations of governmental authorities having jurisdiction thereof.
- I. Indemnification: The Contractor and each Subcontractor covenants and agrees to indemnify, defend and hold harmless the Engineer and Owner against any liability, loss, damage or expenses, including reasonable attorneys' fees, arising from a failure or alleged failure on the part of the contractor, his subcontractor or his or their agents and employees properly to discharge the obligations assumed by him or them in the performance of the work, including any act or omission allegedly resulting in death or personal injury or property damage on improper construction, construction techniques, or the use of improper or inappropriate material or tools.
- J. **[System Downtime: This building is a 24 hour research/classroom/office facility and any shutdown of the supply and exhaust systems or interruption of utility service will be strictly enforced and number of shutdowns must be minimized. Any required shutdowns must be scheduled during weekday evening hours of a duration no longer than 10 consecutive hours, during weekends from 6 PM Friday till 5 AM Monday morning, or as agreed in writing with the OR. Only one power system may be shut down at a time unless required by work on a common item of service and specifically scheduled with the OR. Shutdown of power systems is extremely critical and must be coordinated with the OR before any scheduled shutdown. A**

detailed schedule of activities and system shutdowns is critical and must be submitted to and coordinated with the OR within two weeks of the award of contract. Primary system shutdowns shall be scheduled a minimum of two weeks in advance and reconfirmed 72 hours prior to shutdown. (Note: this exceeds the notice time in the UH Planned and Emergency Utility Outage Policy)The agreed schedule shall be posted in the penthouse and the scheduled shutdown date shall be posted on each piece of equipment and in the affected laboratories. Refer to phasing notes on drawings for additional requirements.]

1. **[Noise and vibrations within the work space must be minimized since it is likely that research will continue in all surrounding spaces. Work that requires loud noise or noticeable vibration must be scheduled with the OR.]**
2. **[Dust and dirt are extremely detrimental to research in adjacent spaces. All duct removal process shall minimize the spread of dirt and dust from the materials removed by isolating the project area from its surroundings.]**
3. **[A schedule will be submitted by the contractor and subsequently reviewed by the building users to determine acceptance or alternative scheduling. All cleaning, treating and coating work shall be undertaken by this contractor using means and methods that minimize odors during working hours.]**

K. Project Completion: All bid submissions, coordination schedules and project staffing shall be based on the critical path to meet the scheduled project completion time.

1.3 CODES, PERMITS AND FEES:

- A. General: The University of Houston complies with state and local codes, and regulatory requirements as listed in the UH Design Guidelines and Standards, Section 12, p2, Facility Performance a.3.b.
- B. Codes and Standards: All work shall be done in full compliance with all applicable state and local codes, requirements and ordinances and applicable requirements of NFPA, UL and other applicable standards.
- C. Industry Standards: All equipment and materials shall be new and listed by the Underwriters' Laboratories, inc., Manufactured in full accordance with applicable ASME, NEMA, ANSI or IEEE standards.
- D. Approvals, Permits and Inspections: Secure and pay for all necessary approvals, permits, inspections, etc., and deliver the official records of the granting of permits to the Owner without additional cost to the Owner.

[EDIT TO SUIT PROJECT]

- E. Code Design Basis: The following codes and ordinances were used in the design of the project and shall be complied with during construction of the project.
1. Building Code - [_____, _____ **Edition.**]
 2. Fire Code - [_____, _____ **Edition.**]
 3. Electrical Code- [_____, _____ **Edition.**]
 4. Mechanical Code- [_____, _____ **Edition.**]
 5. Plumbing Code- [_____, _____ **Edition.**]
 6. Energy Code- [_____, _____ **Edition.**]
 7. Accessibility Code- Texas Accessibility Standards (TAS)/Americans with Disabilities Act of 1990.
- F. 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 Engineer. This Contractor shall report any such modifications to the Engineer and secure his approval before proceeding.

1.4 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 only. It is not the intention of the Engineer 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. The fact that a specific manufacturer is listed as an acceptable manufacturer should not be interpreted to mean that the manufacturers standard product will meet the requirements of the project design, Specifications and space constraints. **The Engineer shall be the sole judge of quality and equivalence of equipment, materials and methods.**

[EDIT TO SUIT PROJECT]

- 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 the Engineer.** 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 the Engineer 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 the Engineer 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. Refer to Division 1, 012500, Substitution Procedures for further information.
- 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 and all materials 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 (US Department of the Army).]**
15. CISPI Cast Iron Soil Pipe Institute.
16. ETL Electrical Testing Laboratory.
17. FM Factory Mutual Engineering Corporation.
18. FS Federal Specification (General Services Administration).
19. IRI Industrial Risk Insurers.
20. MCAA Mechanical Contractors Association of America.
21. **[MIL Military Standardization Documents (U.S. Department 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 (US Department of Labor).
27. PDI Plumbing and Drainage Institute.
28. SMACNA Sheet Metal & Air Conditioning Contractors' National Association.
29. UL Underwriters' Laboratories, Inc.

1.5 SITE VISIT AND FAMILIARIZATION:

- A. General: Become familiar with the 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: Submission of a bid 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.
- D. Pre-Bid Conference: Refer to Division 1.

1.6 DRAWINGS AND SPECIFICATIONS:

- A. General: The Drawings are schematic in nature and indicate approximate locations of the heating, ventilating and air conditioning systems, plumbing equipment, fixtures and piping systems, except where specific locations are noted and dimensioned on the Drawings. All items are shown approximately to scale. The intent is to show how these items shall be integrated into the construction. Locate all items by on the job measurements and in accordance with the Contract Documents. Cooperate with other trades to ensure project completion as indicated.
- B. Location: Prior to locating diffusers, grilles, other exposed air devices, plumbing fixtures, fire hose cabinets, and plumbing items, obtain the Engineer's approval as to exact location. Locations shall not be determined by scaling Drawings. Mount plumbing fixtures, fire hose racks, and cabinets at the heights directed by the Engineer. Contractor shall be responsible for costs of redoing work of trades necessitated by failure to comply with this requirement.
- C. Specifications: The specifications are intended to supplement the Drawings and it is not in the scope of the specifications to mention any part of the work which the Drawings are competent to fully explain. Conversely, any part of the work which the specifications are competent to fully explain, may not be mentioned on the Drawings.
- D. Disagreement: Disagreement between the Drawings or specifications or within the Drawings or specifications shall be estimated using the better quality or greater quantity of material or installation, and a request for information shall be made in writing to the Engineer.

1.7 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. All questions and requests for clarifications shall be submitted in writing to the Engineer.
- 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 the Engineer for such further Drawings or explanations as may be necessary, allowing a reasonable time for the Engineer to respond. The Contractor shall conform to this additional information as a part of the Contract without additional cost to the Owner or Engineer.
- C. Interpretations: Should any doubt or question arise respecting the true meaning of Drawings or Specifications, reference shall be made to the Engineer, whose written decision shall be final and conclusive. No alleged statement by the Engineer 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. Submission of a bid conveys full Contractor agreement of the items and conditions specified, shown, scheduled, or required by the nature of the project.
- E. Discrepancy Notification: Immediately notify engineer in writing when existing field conditions differ from the conditions shown on the contract documents.

1.8 SAFETY REGULATIONS:

- A. General: All electrical 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.

- B. OSHA: It shall be the duty and responsibility of the Contractor and all of its subcontractors to be familiar and comply with all requirements of Public Law 91596, 29 U.S.C. Secs. 651 et seq., the Occupational Safety and Health Act of 1970, (OSHA) and all amendments thereto, and to enforce and comply with all of the provisions of this Act.
- C. Emergencies: In any emergency affecting the safety of persons or property, the Contractor shall act, at its direction, to prevent threatened damage, injury or loss.

1.9 UTILITIES:

- A. General: Utility information shown on the 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 the Engineer.
- B. Coordination: The Contractor shall be responsible for field verification of the actual location of site and/or building utilities and shall make modifications necessary for connection to or construction around those utilities at no additional cost to the Owner or Engineer.

1.10 CHANGE ORDERS:

- A. General: Refer to Uniform General Conditions and Division 1 for requirement concerning Change Orders.

1.11 ALTERNATES:

- A. General: Refer to Division 1 for information concerning Alternates. **[A summary of alternates which impact the work of this Division is as follows:]**

1.12 UNIT PRICES:

- A. General: Refer to Division 1 for information on required Unit Prices which are part of the project bid.

1.13 PRECONSTRUCTION CONFERENCE:

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

1.14 SITE OBSERVATION:

- A. General: Observation at the site to verify general compliance with Contract Documents will be made periodically by the Engineer or his representative. Written observation comments will be submitted to the General Contractor for review and a written response.
- B. Notification: Contractor shall contact Engineer at project milestones so that Engineer can schedule site visit after most of the mechanical and plumbing installation is complete, but before the installations are covered by ceilings, walls, etc.

1.15 REQUESTS FOR INFORMATION (RFI):

- A. General: All Contractor Requests for Information (RFI's) shall be submitted to the Engineer in writing, for response.
- B. Format: All RFI's shall be submitted on a form which has a space for the requested information and the Engineer's response and signature.
- C. RFI Numbering: The method of numbering for RFI's shall be approved by the Architect and Engineer and shall be formatted as follows

RFI-xx.yyy

Where xx = An agreed to text string to identify project and yy.=.The RFI sequence number.

- D. RFI Log: The Contractor shall compile and maintain an RFI Status log which shall be transmitted to the Engineer on a weekly basis in either hardcopy or e-mailed electronic format.
- E. RFI Electronic Submission and Responses: RFI's shall be submitted in electronic form as a .Word or Excel file submitted as an attachment to an e-mail with the RFI name specifically included in the e-mail subject line. Supplemental information associated with an RFI shall be specifically addressed by file name in the RFI and shall be included in PDF file format as an attachment to the RFI e-mail. RFI file names shall match the RFI number. The Engineer's response to an RFI will be a PDF file renamed "E&C Response to RFI-xx.yy" and locked for printing only.
- F. Responses: The Engineer will endeavor to provide RFI response time in the Engineer's office of **[five]** working days after receipt of the RFI by the Engineer.

1.16 PROJECT STATUS REPORTS:

- A. General: Provide a weekly written progress report, coordinated with all trades, to keep the owner informed of the project progress. This report will be enforced and shall be submitted to the OR and include:
 - 1. Project status and activities for the prior week.
 - 2. Schedule update highlighting all variations from the owner approved schedule.
 - 3. A status report for all documents required by the project (submittals, RFI, reports, change order requests, etc.).

1.17 SUBMITTALS:

- A. General: Submittals required for this project shall include, but not be limited to:
 - 1. Shop Drawings and Product Brochure Submittals.
 - 2. Certifications and Test Reports.
 - 3. Operating and Maintenance Manuals.
 - 4. Warranties (Guarantees).
- B. Additional Requirements: Refer to Division 1 for additional submittal requirements.
- C. Shop Drawings and Product Brochure Submittals: The terms "Submittal" and "Shop Drawing" in this Specification are defined as either product literature, samples of equipment or actual Shop Drawings.
- D. Submittal Schedule: The Contractor shall provide a Schedule of Submittals to the Engineer within **[two]** weeks of bid award. This document shall list the submittal number and name for all required submittals for the project and shall include the proposed date on which each required initial submittal

will be issued to the Engineer for review. The schedule shall allow adequate time to complete the submittal process at times appropriate to the construction schedule while allowing for delivery time to and from the Engineer and Engineer review time. The schedule shall also allow for submittal resubmissions and related delivery and Engineer review time, as may be required. The Engineer shall not be held responsible for delays or costs incurred due to excessive Shop Drawing review time where the initial submittal is received after the scheduled issue date or is not in compliance with submittal requirements contained herein.

- E. Submittal Log: The Contractor shall compile and maintain a Submittal Status log which shall be transmitted to the Engineer on a weekly basis in either hardcopy or e-mailed electronic format.
- F. Submittal Copies: The Contractor shall forward one copy of each submittal to the Architect[, **one copy of each submittal to the Owner**] and the remaining copies of each submittal to the Engineer. The Architect[**and Owner**] will retain their submittal review copies for their files. The Engineer will retain one submittal review copy for our files and will return the remaining submittal review copies to the Contractor, via the Architect/Owner as applicable. The Contractor shall submit additional submittal copies to the Engineer as required for the Contractor's use, including the one copy of each final approved submittal which the Contractor is required to include in the project O&M manuals. Where an alternate submittal review process such as electronic submittal review comments is to be used on a project, then the submittal procedures for that process will be determined and documented at the pre-construction conference.
- G. Shop Drawings and Product Brochure Submittal Requirements: The 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 "REVISE AND RESUBMIT" 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 " REVISE AND RESUBMIT " and returned to the Contractor:
1. Cover Sheet: The cover sheet shall include the Project Name and the names and addresses of the Owner, Project, Architect, M/E/P Engineer, General Contractor 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 the submittal number. HVAC, plumbing and fire protection submittals shall be numbered sequentially by Specification section with a sequence suffix (e.g. 23 31 13-1, 23 31 13-2, 23 31 14-1, etc.). Resubmittals shall be numbered with the original submittal number plus an R in the sequence suffix (e.g. the resubmittals of submittal 23 31 13-1 would be 23 31 13-1R1, 23 31 13-1R2, ...).
 2. Index: The index page shall include a listing of all data included in the submittal.
 3. 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 additional costs to the affected contractors associated with the variations shall be paid by the submitting contractor.
 4. Specification Review. A copy of the appropriate specification section shall be included in the submittal with each specification paragraph marked in the right margin with a "C" for Submitted Product/Material/Installation Complies or an "N" for Submitted Product/Material/Installation Not In Compliance. All paragraphs marked with a "N" shall be specifically addressed in the Submittal List of Variations.
 5. Equipment Information: Submittal shall include equipment information including manufacturer's name and designation, size, performance and capacity data. All applicable listings, labels, approvals and standards shall be clearly indicated.
 6. Dimensional Data: Submittal shall include 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.

7. Identification Information: Submittal shall include Identification/designation for each item of material or equipment matching that indicated in the Specifications or on the Drawings.
 8. Product Data: Submittal shall include sufficient pictorial, descriptive and diagrammatic data on each item to show its conformance with the 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.
 9. Contractor Certification: Submittal shall include certification by the General Contractor and Subcontractor that the material submitted is in accordance with the Contract Documents, signed and dated.
 10. Manufacturer Certification: Where specified, submittals shall include reports or information requiring certification which shall be certified by an authorized officer of the manufacturer or testing agency.
 11. Certified Shop Drawings: Submittals shall include 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.
 12. Equipment/Material Data: 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.
 13. Additional Information: Submittal shall include additional information as required in other sections of this Division.
- H. Required Shop Drawing Submittals: Submit Shop Drawings, including, but not limited to the following items:
1. Schedule of Submittals Refer to Section 23 01 00.
 2. Testing, Adjustment and Balancing Refer to Section 23 05 93.
 - a. Before starting the actual Test and Balance procedure submit:
Personnel qualifications.
Equipment to be used on the project.
Testing and Balancing Forms.
 3. Basic Materials and Methods Refer to Section 23 03 00.
 4. Pipe Heat Tracing Refer to Section 23 04 05.
 5. Electronic Variable Speed Drives Refer to Section 23 05 10.
 6. Motors and Controllers Refer to Section 23 04 00.
 7. System Insulation Refer to Section 23 07 00.
 8. Vibration Isolation Refer to Section 23 05 48.
 9. Plumbing Pumps Refer to Section 22 10 00.
 10. Electric Water Heaters Refer to Section 22 12 00.
 11. House/Break Tanks Refer to Section 22 13 00.
 12. Water Treatment Equipment Refer to Section 23 25 00.
 13. Plumbing Piping Systems Refer to Section 22 10 20.
 14. Plumbing Valves and Accessories Refer to Section 22 10 10.
 15. Plumbing Fixtures and Trim Refer to Section 22 30 00.
 16. Floor, Area and Roof Drains Refer to Section 22 40 00.
 17. Fire Protection System Refer to Section 21 12 00.
 18. Wet-Pipe Fire Sprinkler System Refer to Section 21 13 13.
 19. Fire Protection Pumps Refer to Section 21 30 00.
 20. HVAC Pumps Refer to Section 23 30 00.
 21. HVAC Piping Systems Refer to Section 23 20 00.

22. HVAC Piping Valves and Accessories	Refer to Section 23 20 10.
23. HVAC Water Treatment	Refer to Section 23 25 00.
24. Heat Exchangers	Refer to Section 23 12 00.
25. Custom Air Handling Units	Refer to Section 23 74 20.
26. HVAC Coils	Refer to Section 23 82 16.
27. Fans, Air Intakes and Relief Vents	Refer to Section 23 82 20.
28. HVAC Terminal Units	Refer to Section 23 36 00.
29. Ductwork	Refer to Section 23 31 13.
30. Ductwork Accessories	Refer to Section 23 31 14.
31. Air Distribution Devices	Refer to Section 23 37 13.
32. Filters and Accessories	Refer to Section 23 41 13.
33. Building Controls	Refer to Section 23 06 00.
34. Coordination Drawings	Refer to Section 23 01 00.

[SPECIFIER TO PREPARE A CHECKLIST OF REQUIRED SHOP DRAWING]

- I. Samples: Submit two samples, upon request, of mechanical/plumbing devices and materials for review by the Architect/Engineer. Samples will be returned upon written request of the Contractor.
- J. Fabrication Drawings: Fabrication Drawings shall be made at no additional charge to the Owner or the Architect/Engineer. Submit Fabrication Drawings whenever:
 1. Equipment proposed varies in physical size and arrangement from that indicated on the Drawings, thus causing rearrangement of equipment space.
 2. Where tight spaces require extreme coordination between ductwork, piping, conduit and other equipment.
 3. Where called for elsewhere in these Specifications.
 4. Where specifically requested by the Architect/Engineer.
- K. Equipment List: Within thirty days after the date of contract award or work order, whichever is later, and before purchasing or starting installation of materials or equipment, the Contractor shall submit for review, a complete list of suppliers, contractors and manufacturers for all materials and equipment which will be submitted for incorporation into the project. The list shall be arranged in accordance with the organization of the Specifications.
 1. This initial list shall include the manufacturer's name and type or catalog number as required to identify the quality of material or equipment proposed.
 2. This initial list shall include the proposed submittal schedule to allow the design team to schedule the required time for reviews.
 3. This list will be reviewed by the Engineer and the Owner and will be returned to the Contractor with comments as to which items are acceptable without further submittal data and which items will require detailed submittal data for further review and subsequent approval.
 4. The initial list shall be submitted as herein specified. Materials and equipment requiring detailed submittal data shall be submitted with sufficient data to indicate that all requirements of these Specifications have been met and samples shall be furnished when requested. All manufacturer's data used as part of the submittal shall have all inapplicable features crossed out or deleted in a manner that will clearly indicate exactly what is to be furnished.
- L. 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 which 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 Engineer will endeavor to provide Shop Drawing review time in the Engineer's office of 2 weeks per review, exclusive of transmittal time, and this review time shall be considered by the

- Contractor when scheduling his work on the project. Submittals received outside the scheduled delivery dates may require additional time for review.
2. The Architect's review or approval and the Engineer's review of Shop Drawings 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 the Engineer's review thereof, the Contract Documents shall govern the Work and are neither waived or superseded by the Shop Drawing review.
 3. It shall be the responsibility of the submitting Contractor to check all equipment and materials for conformance with the Contract Documents and a "REVIEWED WITH NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED" submittal at the time such equipment and materials are delivered to the job site, and to notify the Engineer of any deviations.
 4. Inadequate or incomplete Shop Drawings will not be reviewed by the Architect or the Engineer and will be returned to the Contractor marked " REVISE AND RESUBMIT " for completion and resubmittal.
 5. Shop Drawings will be marked "REVIEWED WITH NO EXCEPTIONS TAKEN", "MAKE CORRECTIONS NOTED AND SUBMIT WRITTEN RESPONSE", "REVISE AND RESUBMIT", or "REJECTED" when reviewed by the Engineer. The definitions of these terms for submittal review purposes is as follows:
 - a. **REVIEWED WITH NO EXCEPTIONS TAKEN** - The Shop Drawing was reviewed and no exceptions from the general conformance with the design concept and general compliance with the information given in the Contract Documents were noted.
 - b. **MAKE CORRECTIONS NOTED AND SUBMIT WRITTEN RESPONSE** - The Shop Drawing was reviewed and found to have either minor deviations from the requirements of the Contract Documents or information missing from the submittal, as noted. 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. **REJECTED** - 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 without an "REVIEWED WITH NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED" 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 the Architect/Engineer for any reason, shall be at the expense of the Contractor.
 8. Shop Drawings shall be complete and checked prior to submission to the Engineer for review. **Where more than two reviews are required for a given Shop Drawing to reach "REVIEWED WITH NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED AND SUBMIT WRITTEN RESPONSE" status, the Contractor will be invoiced for additional review services at a cost of \$150.00 per hour for review of the third and subsequent submittals.** If the Contractor fails to pay any legitimate additional review services invoice in full within 30 days, then that invoice will be forwarded to the Architect/Owner requesting that to withhold payment of the amount invoiced from the next General Contractors request for payment, as allowed for under UH Owner-

Contractor Agreement and Construction Manager-At-Risk Agreement. Incomplete submittals will be returned to the Contractor unchecked.

- M. Certifications and Test Reports: The Engineer may, at their option, witness any or all of the on and off site acceptance and operational testing. Submit a detailed listing of certification and testing for each system indicating estimated dates for completion of system installation. This listing of certification and testing shall be submitted at least 30 days before any testing is conducted.
1. Test procedures and test result reporting forms shall be submitted for review no later than the date of the certification and testing listing submittal.
 2. Notify the Engineer in writing two weeks prior to any scheduled testing to allow time for Engineer to schedule witnessing of testing, where elected by the Engineer.
 3. Submit six copies of all certifications and test reports to the Engineer for review adequately in advance of completion of the Work to allow for remedial action as required to correct deficiencies discovered in equipment and systems.
 4. Certifications and test reports to be submitted shall include, but not be limited to those items outlined in Section 15020, "Testing, Adjustment and Balancing".

N. Operating and Maintenance Manuals:

Hard copies: Submit two copies of Operating and Maintenance Manuals to the Engineer for approval prior to the beginning of operator training. Provide four approved Operating and Maintenance Manuals for use in operator training. 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 which 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 which shall, likewise, be bound with bulletins.

Electronic copies: Submit an additional copy of information described above in electronic format.

At 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, including sources for all parts.
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, 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. 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.
5. Identifying names, name tags designations and locations for all equipment.
6. Valve tag lists with valve number, type, color coding, location and function.
7. Equipment and motor nameplate data.
8. Copies of all approved Shop Drawing submittals and testing and balancing reports.
9. Fabrication drawings.
10. Equipment and device bulletins and cutsheets clearly highlighted to show equipment installed on the project and including performance curves and data as applicable.

- 11. Maintenance instructions clearly highlighted to show all required periodic maintenance and lubrication.
 - 12. Wiring diagrams.
 - 13. Operating instructions clearly highlighted to show proper operating procedures for all equipment.
 - 14. Exploded parts views and parts lists for all equipment and devices.
 - 15. Color coding charts for all painted equipment and conduit.
 - 16. Location and listing of all spare parts and special keys and tools furnished to the Owner.
- O. Tools: Provide and deliver to the Owner's authorized representative any special tools required for maintenance of systems, equipment, and apparatus installed under this Division prior to requesting final acceptance of the installation.
- 1.18 PROJECT RECORD DOCUMENTS: See also FP&C Project Controls and Construction Inspections Procedure 1.13 – Inspection Record Drawings (Management).
- 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 Engineers name and seal removed or blacked out and shall be clearly marked and signed on each sheet as follows:

CERTIFIED RECORD DRAWINGS

DATE: _____

(NAME OF GENERAL CONTRACTOR)

BY: (SIGNATURE)

(NAME OF SUBCONTRACTOR)

BY: (SIGNATURE)

- C. Approval: 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 Engineer for review and shall make changes, corrections, or additions as the Engineer may require to the Record Drawings.
- 1.19 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 which must be established within the mechanical work, and in its interface with other work including 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 and with a minimum of 7' overhead clearance where possible.

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 the Engineer. Relocations necessitated by the conditions at the site or directed by the Engineer shall be made without any additional cost to the Owner or Engineer.
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 furrings, 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 the Engineer and shall stop work in those areas until the Owner's Representative or General Contractor directs the resumption of the work. Submit for approval a Shop Drawing for any change in piping, equipment placement, ductwork, etc.
4. Equipment has been 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 interferences shall be handled by giving precedence to pipe lines which 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. Steam and 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.
 - 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.
8. Coordinate all items which will affect the installation of the work of this Division. This coordination shall include, but not be limited to, 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 Drawings:

1. Coordinate the work of all Subcontractors for this Division with the Contractors responsible for this and other Divisions. Provide, in writing (with copies to the Engineer, Architect and Owner) all information necessary for coordination to permit the work of the project, including all Divisions, to be installed satisfactorily and with the least possible interference or delay.

2. The Division 15 Contractors, in coordination with Contractors responsible for other Divisions, shall prepare a complete set of construction "Coordination Drawings" which shall be completed and submitted to the Engineer, Architect and Owner within **[two (2)] [three (3)]** months after notice to proceed is given to the General Contractor. **If the General Contractor or any Subcontractor allows any work to be installed before coordinating with the work of other Subcontractors, the necessary changes for field coordination shall be made without extra cost to the Owner.**
3. "Coordination Drawings" shall be drawn at a scale of not less than 1/4" = 1'0" and shall be bond CAD plots. Drawings shall show actual equipment being provided and shall maintain all design drawing space allocations, designated dimensions, ceiling heights, chase dimensions, room sizes and service clearances recommended by the manufacturer of the equipment being provided. Deviations from ceiling heights, chase dimensions, room sizes and similar requirements on the Construction Documents shall not be made without specific prior written authorization from the Architect.
4. "Coordination Drawings" for interior construction shall show the coordinated locations for equipment, ductwork, piping, conduit, busway, devices, etc. and shall show all ductwork, all busway and all pipe and conduit larger than 4" using double lines. Elevations shall be shown for all construction and horizontal dimensions from major construction to accessible column or building lines shall be shown. Where required for coordination, offsets shall be shown and sections shall be cut and drawn.
5. "Coordination Drawings" shall indicate loads and anchor/support points for all piping 8" and larger, for all racked piping, for all racked conduit 3" and larger, for all busway and for all suspended equipment. These drawings shall be submitted to the Structural Engineer for review and approval. Any special hangers, embeds, supports, reinforcing, etc. required by the Structural Engineer shall be provided at no additional cost to the Owner.
6. "Coordination Drawings" for all work routed underground or embedded in concrete shall show specific dimensions to accessible column or building lines and the burial depth of all underground utilities. Where existing utilities are located in the area where new utilities are being installed, dimensions and burial depth for existing utilities shall be shown on "Coordination Drawings".
7. Each "Coordination Drawing" shall be completed and signed off by the General Contractor and all applicable Subcontractors prior to submission to the Architect, Engineer and Owner for submittal review, prior to installation of Division 23 or 26 work in the area covered by the specific coordination drawing.
8. The requirement for "Coordination Drawings" shall not be construed as releasing the General Contractor or Subcontractors from their responsibility to coordinate the installation of the work or as authorization for the General Contractor or Subcontractors to make unauthorized changes to the Construction Documents or the project design concepts.

1.20 MATERIALS AND WORKMANSHIP:

- A. General: Materials and equipment shall be new, of best grade and quality, and standard products of reputable manufacturers 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.

1.21 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.

- 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 initial access and proper fit rests with the Contractor.
- E. Review: Final arrangements of equipment to be installed shall be subject to the Architect's review.

1.22 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.

1.23 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. Unloading, moving, and storage on site with proper protection as required.
 - 3. Hoisting and scaffolding of materials and equipment included in this Division.
 - 4. Ensuring safety of employees, materials, and equipment using such hoisting equipment and scaffolding.
- C. Installation Coordination: All large pieces of apparatus which are to be installed in the building and which are too large to permit access through doorways, corridors, stairways or shafts shall be brought to the job by the Contractor and shall be placed in the spaces before enclosing partitions and structure are completed.
- D. Protection: All equipment, materials and apparatus stored outdoors, in unenclosed spaces or in enclosed spaces at the jobsite or at the Subcontractor's facilities shall be protected against temperatures ranging from **[20°F to 105°F]**, rain, wind, hail and all other weather conditions that are common to the site location.
 - 1. Storage Outdoors: All equipment, materials and apparatus stored outdoors shall be cribbed up from the ground by Contractor and shall be covered with tarpaulins or other protective covering as required for protection. Provide temporary space conditioning inside protective enclosures as required to properly protect equipment, materials and apparatus.
 - 2. Storage in an Unenclosed Building: All equipment, materials and apparatus stored in an unenclosed building shall be cribbed up from the floor by Contractor and shall be covered with tarpaulins or other protective covering as required for protection. Provide temporary space conditioning inside protective enclosures as required to properly protect equipment, materials and apparatus.
 - 3. Storage in and Enclosed Building: All equipment, materials and apparatus stored in an enclosed building shall be cribbed up from the floor by Contractor and shall be covered with tarpaulins or other protective covering as required for protection. Provide temporary space conditioning as required to properly protect equipment, materials and apparatus which are stored in unconditioned buildings from damage.

1.24 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 NC curves (refer to ASHRAE Standard) 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.
- B. Sound Testing: Equipment shall be sound tested as specified in the individual Sections. The test data shall be expressed in sound power levels with decibels referenced to 10^{-12} watts and in octave bands as set forth in current ANSI Standards. The sound testing shall be performed in a reverberant room. The room effect shall be defined as the sound power level (decibels referenced to 10^{-12} watts) minus

sound pressure level (decibels referenced to 0.0002 microbar) shall be established at 10 dB. The additive "allowance for multiple air outlets" for the purpose of the sound test shall be considered as 5 dB in determining the sound power level per air terminal. The final sound pressure level test results shall be based on the above requirements unless noted or specified otherwise and shall not exceed the noise criteria curve limitations specified.

- C. Noise Level: Except in special areas listed separately, the noise level in occupied spaces shall be equal to, or less than, the "lowest value in the range" of the noise criteria curves for the particular space in accordance with Chapter 7, Table 11 of the 2009 Fundamentals Edition of the ASHRAE Handbook. The noise criteria curves shall be based on current ANSI Standard octave bands and a sound pressure level in decibels referenced to 0.0002 microbars. Sound levels within the occupied spaces must meet the criteria described above and with all building, wall partition, floor, and ceiling construction in place as they exist for the individual spaces. The attenuation through boundary construction of equipment rooms must be considered in selecting equipment for acceptable noise level.
- 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.

1.25 ADJUSTING AND START-UP:

- A. Start-up Services: Where specified for any individual item of heating, ventilating, air conditioning, and plumbing equipment, provide a factory-authorized representative for testing, start-up of equipment, and instruction of Owner's operating personnel. Certify that these services have been performed by including a properly executed invoice for these services or a letter from the manufacturer.
- B. Lubrication: Provide a readily accessible means for lubricating all bearings and other machine parts. 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: Air filters shall be installed on all equipment so equipped prior to initial start-up. In addition, blanket filters shall be installed over coils, filters and over fan powered terminal unit inlets as a pre-filter during construction. Final filters shall be installed prior to the owner's beneficial use (substantial completion)
- D. Testing, Adjusting and Balance: Refer to Section 230593 for requirements.
- E. Operation Prior to Completion: When any piece of mechanical equipment is operable and it is to the advantage of the Contractor to operate the equipment, he may do so, providing that he properly supervises the operation, and has the Engineer's written permission to do so. The warranty period shall, however, not commence until such time as the equipment is operated for the beneficial use of the Owner, or the date of substantial completion, whichever occurs first. Regardless of whether or not the equipment has or has not been operated the Contractor shall properly clean the equipment, install clean filter media, properly adjust and complete all deficiency list items before final acceptance by the Owner. The date of final acceptance and the start of the warranty may not be the same date.

[EDIT TO SUIT PROJECT]

1.26 SITE CLEAN-UP:

- A. 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, clean, operable condition.
- B. Clean Work Space: If the facility will remain occupied during the construction process, each Contractor shall clean up and maintain, at all times, areas visible to the public to prevent the appearance of a sloppy or careless work space. Employee trash shall be disposed of in a designated trash receptacle maintained by the contractor. All demolition or construction debris not designated for salvage by the Project Manager shall daily be collected and temporarily held in an area designated by,

and in quantities allowed by, the owner or the general contractor, or the contractor shall be removed from the site by this contractor and disposed of properly off site.

- C. Salvageable Materials: Materials designated by the OR to be salvaged shall be stored in the building, at a location as directed by the OR and the contractor shall verify with the OR which materials are to be salvaged.
- D. Continuing Facilities Maintenance: In areas that contain equipment or systems that must be serviced, inspected, or maintained, no construction debris shall be allowed to block normal access paths or inhibit the required maintenance or service of those systems. This contractor shall immediately remove any debris that constitutes a hindrance to normal service.
- E. Directed Clean-Up: If the facility will remain occupied during the construction process, should, for any reason, the OR, the Architect or the Engineer notify the contractor of his failure to comply with a clean work space requirement, and the contractor ignores this requirement, the Owner shall retain the services of a clean-up crew to maintain a clean public work space and back charge the contractor for such contract costs.
- F. Daily Clean-Up: Each Contractor shall clean away from the job site all debris, surplus material, and similar items, resulting from his work or operations, on a daily basis leaving the job and equipment in a clean condition. Each Contractor shall thoroughly clean all pieces of equipment, fixtures, and similar items, leaving the installation in a first class, clean, operable condition.

1.27 POLICIES AND PROCEDURES

- A. Employees: Employees of the contractor that are assigned to this project shall be competent, experienced personnel who have received training for their related tasks and in the operation of any equipment that they are to operate.
- B. Identification: Employees shall be uniformed or wear clothing that clearly distinguishes them as employees of the contractor or subcontractors authorized to provide services at this facility. In addition, employees shall have picture identification badges of a type acceptable to the Owner.
- C. Supervision: Each work crew on the project shall include a full time site foreman or supervisor.
- D. Contact: The contractor shall provide a contact point, available by phone or pager, who will respond immediately to problems, questions or concerns reported by the OR.
- E. Training: Employees shall be trained in any required safety precautions related to the equipment and materials that they are using.

1.28 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 the Engineer at least one week prior to the review.
- B. Qualified Person: Individuals knowledgeable of the systems and persons approved by the Engineer, shall be present at this final inspection to demonstrate the system and prove the performance of the equipment.

1.29 OWNER INSTRUCTION:

- A. General: This Contractor and appropriate factory-trained representatives shall provide to the Owner's representative the specified or manufacturer recommended training and instruction 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 the Engineer.
- 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 23 Sections for additional operator training requirements.

1.30 CONTRACTOR WARRANTIES AND GUARANTEES:

- A. General: Contractor shall guarantee all material and equipment installed by him against defects in workmanship and material for a period of 12 months after final acceptance of the work by the Owner and he 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, such as motors, compressors, condensers, heat exchangers, water heaters, blowers, controls, and similar items, shall be construed to have an extended guarantee 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.

PART 2 - PRODUCTS

Not applicable.

PART 3 - EXECUTION

Not applicable.

END OF SECTION 23 01 00

SECTION 23 03 00 - BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide basic materials and methods for mechanical construction as shown, scheduled, indicated, and specified.
- B. Types: The types of basic materials and methods required for the project include, but are not limited to:

1. General piping installation.
2. Hangers and supports.
3. Miscellaneous steel.
4. Sleeves.
5. Escutcheon plates.
6. Exposed piping.
7. Pipe cleaning and sterilization.
8. Openings, cutting and patching.
9. Excavation, trenching, and backfilling.
10. Access doors.
11. Firestopping for piping and ductwork.
12. Fire-rated partitions.
13. Flame spread properties of materials.
14. Penetrations, flashing, and seals.
15. Cleaning and painting of mechanical work.
16. Mechanical system identification.
17. Warning signs and operational tags.
18. Prohibited markings.
19. Tamper resistant fasteners.
20. Equipment connections.
21. Rotating shafts.
22. Belt and coupling guards.
23. Bearings.
24. Equipment housekeeping pads and anchor bolts.
25. Miscellaneous curbs and supports.
26. Device mounting heights.
27. [Demolition and work within existing buildings.]

1.3 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
 1. Pipe fabrication drawings.
 2. Cut sheets on pipe hangers and supports, escutcheons, access doors, fire stopping materials, and miscellaneous curbs and supports.
 3. [Excavation and trenching plan, designed and sealed by a registered professional engineer. Refer to Division 1 for additional submittal requirements.]

4. Cut sheets and samples of mechanical identification products.
5. Additional information as required in Section 23 01 00.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver components in factory-fabricated water resistant packaging.
- B. Handle components carefully to avoid damage to components, enclosures, and finish.
- C. Store components in a clean, dry space and protect from weather.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. General: Refer to Part 3 of this Section and other Division 23 sections for basic mechanical products and materials.

PART 3 - EXECUTION

3.1 GENERAL PIPING INSTALLATION:

- A. General: The Contractor shall provide all piping system components as shown on the Drawings or necessary to complete the working system in accordance with the intent of the Drawings and Specifications, a complete system of piping, all valves as indicated or as necessary to completely control the entire apparatus and all appurtenances. The Piping Drawings are diagrammatic and indicate the general location and connections.
- B. Erection: Piping shall be properly supported and adequate provisions shall be made for expansion, contraction, slope and anchorage. All piping shall be cut accurately for fabrication to measurements established at the construction site. Pipe shall be worked in place without springing or forcing. Cutting or other weakening of the building structure to facilitate installation will not be permitted. All pipes shall have burr and cutting slag removed by reaming or other approved cleaning methods. All changes in direction shall be made with fittings, except that bending of pipe will be permitted provided a hydraulic pipe bender is used. Bent pipe showing kinks, wrinkles, or other malformation will not be acceptable.
- C. Concealed and Exposed Piping: All piping in finished areas shall be concealed, unless otherwise noted. Piping exposed in mechanical rooms and other locations as noted shall be installed in an orderly manner and parallel with or perpendicular to building lines. Exposed piping in occupied areas shall be routed tight to the structure or as high as is possible.
- D. Grading: All piping shall be carefully installed so as to eliminate traps and pockets in pressurized lines and to maintain flow in gravity flow lines. Where air pockets and traps cannot be avoided, provide valved hose connections for water traps and valved automatic air vents for air traps. The Contractor shall consider pipe grading requirements when coordinating pipe routing for the project. Pipe slope shall be maintained throughout the project. Waste and vent piping shall be sloped in accordance with the applicable codes. Pressurized plumbing piping systems shall be sloped to drain points. HVAC water piping systems shall be graded up 1/16" per 10 lineal foot of horizontal run to air vent locations and down 1/16" per 10 lineal feet of horizontal run to drain locations. Grade all steam piping 1/4" per 10 lineal feet of horizontal run toward steam traps and slope all steam condensate piping 1/4" per 10 lineal feet of horizontal run toward condensate receivers.
- E. Arrangement: Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment. All valves and specialties shall be placed to permit easy and proper operation and access, and all valves shall be regulated, packed and glands adjusted at the completion of the work before final acceptance. Tapered reducers shall be used wherever changes in pipe sizes occur in mains. Bushings will not be permitted. The use of bull head tees or other high pressure drop configurations will not be permitted.
- F. Welding: All welded joints in piping shall be continuous metallic arc or gas fusion welds connecting pipe ends which are beveled to 37-1/2 degrees before welding. The use of backing rings will not be acceptable. All taps shall be made using proper weld fittings. No "burn-ins" will be allowed. Gas torch cuts shall be true and free from burned metal. Clean pipe surfaces to be welded immediately prior to welding. Welded pipe joints shall be properly aligned with no weld material or bead projects in into the pipe. All weld procedures shall be in accordance with requirements of the American Welding Society

and shall be performed by certified welders. Documentation of welder certification shall be available if requested. All welding operations shall conform to the latest recommendations of the American Welding Society and to Section Six of Power Piping, ANSI B31.1 1973; B31.3 for steam piping. All qualifying tests, welding and stress relieving procedures, shall, moreover, be in accord with Standard Qualification for WELDING PROCEDURES, WELDERS AND WELDING OPERATORS, APPENDIX A, SECTION 6 of the Code, current edition. In no cases shall Schedule 40 pipe be welded with less than three passes including one tack, one filler, and one lacer. Schedule 80 pipe shall be welded with not less than four passes including one tack, two fillers and one lacer. Welds lacking penetration shall be removed. Internal and external cracks shall be ground down and removed.

1. All weld fittings shall be USA factory made wrought carbon steel butt-welding fittings conforming to ASTM A234 and ASME/ANSI B16.9 latest edition, as made by aNVIL, Tube Turn, Hackney, Taylor Forge, or Ladish Company. Long radius fittings shall be provided for all 90 degree and 45 degree elbows. Each fitting shall be stamped as specified by ASME/ANSI B16.9 and, in addition, shall have the laboratory control number metal stenciled on each fitting for ready reference as to physical properties required for any fitting selected at random. Complete test reports may be required for any fittings selected at random. Only one manufacturer of weld fittings will be approved for each project. Fittings which have been machined, remarked, printed or otherwise produced domestically from imported forgings or materials will not be acceptable. Each fitting shall have the manufacturer's trademark permanently identified in accordance with MSS SP-25. Markings shall be placed on the fittings at the farthest point from the edge to be welded to prevent disfiguring from the welding process. Submittal data for these fittings shall include a letter signed by an official of the manufacturing firm certifying compliance with these Specifications.
2. Piping and fittings shall be welded and fabricated in accordance with ASME/ANSI and the latest edition of Standard B31.1 from the Code for Pressure Piping for all systems, and B31.3 for Steam and Condensate systems. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.
3. Ensure complete penetration of deposited metal with base metal. Contractor shall provide filler metal suitable for use with base metal. Keep inside of fittings free from globules of weld metal.
4. Align piping and equipment so that no part is offset more than 1/16". Set all fittings and joints square and true, and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.
5. Do not permit any weld to project within the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.
6. Contractor shall not split, bend, flatten or otherwise damage piping before, during or after installation. Remove dirt, scale, and other foreign matter from inside piping before tying in sections, fittings, valves or equipment.
7. In no case shall Schedule 40 pipe be welded with less than three passes including one stringer/root, one filler and one lacer. Schedule 80 pipe shall be welded with not less than four passes including one stringer/root, two fillers and one lacer. In all cases, however, the weld must be filled before the cap weld is added.
8. All welds are subject to inspection, visual and/or X-ray, for compliance with specifications. The Owner will, at the Owners option, provide employees or employ a testing laboratory for the purposes of performing said inspections and/or X-ray testing. Initial visual and X-ray inspections will be provided by the Owner. The Contractor shall be responsible for all labor, material and travel expenses involved in the reinspection and retesting of any welds found to be unacceptable. In addition, the Contractor shall be responsible for the costs involved in any and all additional testing required or recommended by ASME/ANSI Standards B31.1 and B31.3 due to the discovery of poor, unacceptable, or rejected welds.
9. Welds lacking penetration, containing excessive porosity or cracks, or are found to be unacceptable for any reason, must be removed and replaced with an original quality weld as specified herein. All qualifying tests, welding, and stress relieving procedures shall, moreover, be

in accord with Standard Qualification for Welding Procedures, Welders and Welding Operators, Appendix A, Section 6 of the Code, current edition.

- G. Screw Pipe Fittings: All screw joints shall be made with taper threads, properly cut. Joints shall be made tight with teflon applied to the pipe threads only and not to fittings. When threads are cut on pipes, the ends shall be carefully reamed to remove any burrs. Before installing pipe that has been cut and threaded, the lengths of pipe shall be upended and hammered to remove all shavings and foreign material.
- H. Assembling Other Joints: Procedures for assembling joints in cast iron and copper lines have been set forth elsewhere in these Specifications. For any special materials, consult the manufacturers for the recommended procedures in assembling the joints.
- I. Expansion and Contraction: Provisions for expansion and contraction of piping shall be provided by expansion loops, bends or expansion joints to prevent injury to connections, piping, equipment or the elements of the building.
- J. Anchors: Pipe anchors shall be provided and installed at each end of piping runs which require expansion loops or joints, and where indicated on Drawings. Anchors shall be fabricated of rigid structured steel members firmly secured to the building structure.
- K. Guides: Pipe guides shall be provided and installed on piping as shown on Drawings and as necessary to properly fulfill function of expansion loops.
- L. Unions: Shall be installed on all bypasses, ahead of all traps, at all connections to equipment, where shown on the Drawings or where required to facilitate removal of equipment.
- M. Escutcheons: Spring clamp plates (escutcheons) shall be provided where pipes are exposed in finish locations of the building and run through walls, floors, or ceilings. Plates shall be chrome plated spun brass of plain or approved pattern and shall be set tight on the pipe and to the building surface.
- N. Protection: All open ends of pipes and equipment shall be properly capped or plugged during construction to keep dirt and other foreign materials out of the system. Plugs of rags, wool, cotton, waste or similar materials are not acceptable.
- O. Pipe Sizes: If the size of the piping is not clearly evident in the Drawings, the Contractor shall request instruction as to the proper sizing.
- P. Connections Between Copper and Steel Pipes: Connections shall be made with dielectric couplings, flanged dielectric unions, CTS copper flanged adapter or nylon bushings temperature and pressure rated for the service at the point of installation.
- Q. Exterior Underground Piping: All exterior underground piping shall be installed with a minimum of 30" of earth or equivalent cover, except where specifically shown otherwise or permitted by the Architect/Engineer. Generally more cover shall be provided if the grades of the lines involved and the finished grade elevations established at the site will permit.
- R. Pipe Layout: All piping shall be installed in accordance with Plans and Specifications and according to all applicable local and state codes. Minor piping revisions due to substituted equipment are acceptable provided they are indicated on piping fabrication drawings. All the various piping systems shall be made up straight and true and run at proper grades to permit proper flow of the contained material. Lines shall also be graded for proper drainage. Piping shall follow as closely as possible the routes shown on Drawings which take into consideration conditions to be met at the site. Should any unforeseen conditions arise, lines shall be changed or rerouted as required after proper approval has been obtained. All piping shall be installed with due regard to expansion and contraction and so as to prevent excessive strain and stress in the piping, in connections, and in equipment to which the lines are connected. All piping shall be clean when it is installed. Before installation it shall be checked, upended, swabbed, if necessary, and all rust or dirt from storage or from laying on the ground shall be removed.
- S. Piping fabrication drawings shall be submitted for all piping in the Central Plant, mechanical rooms, and for equipment connections and all other areas requiring coordination with other trades.
 - 1. Pipe fabrication drawings shall be double line drawings to scale on 1/4" scale building floor plans and shall indicate pipe size, fittings, valves, accessories, connections, system type, insulation,

hangers, support requirements, anchors, guides, expansion joints and loops, pipe elevations and other information required for coordination with other trades and fabrication of piping.

2. Pipe fabrication drawings shall be coordinated with other trades and building construction prior to submittal for approval. Refer to Section 23 01 00 for additional shop drawing requirements.

3.2 HANGERS AND SUPPORTS:

- A. General: Provide pipe hangers and supports as specified. All horizontal and vertical piping shall be thoroughly and substantially supported in ANSI B31.1 Standard Code for Pressure Piping and Manufacturers' Standardization Society MSS SP-69 Pipe Hangers and Supports - Selection and Application. Comply with local codes and standards for pipe and equipment support and anchorage. Pipe supports shall be of material that will prevent electrolytic action. The design, type, spacing and application of all hangers, supports, anchors and guides shall comply with the above standards. Hanger rod clamps and inserts shall be as recommended by the clamp or insert manufacturer for the intended use and shall be approved in writing by the Structural Engineer. All methods of attachment to the structure and the use of afterset inserts shall be approved in writing by the Structural Engineer. **The load and spacing on each hanger and/or insert shall not exceed the safe allowable load for any component of the support system, including the concrete which holds the inserts.** Reinforcement at inserts shall be provided as required to develop the strength required.
- B. 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.
- C. Acceptable Manufacturers: The model numbers listed in the Specification establish a level of quality and material. The following manufacturers are acceptable subject to compliance with the requirements of this Specification:
 1. Anvil International.
 2. B-Line.
 3. Central Iron Manufacturing Company.
 4. F & S Manufacturing Company.
 5. Hubbard Enterprises/Holdrite
 6. The Michigan Hanger Company.
- D. Inserts: Provide Anvil Fig. 282 or equal inserts for all pipe, ductwork and equipment suspended from new concrete construction. Where inserts are placed in the bottom faces of concrete joists which are too narrow to provide adequate strength of concrete to hold the insert properly or where a larger insert would require displacement of the bottom joist steel, the hanger rod shall be suspended from the center of a horizontal angle iron, channel iron, I-beam, and similar items spanning across two adjacent joists. The horizontal support shall be bolted to nonadjustable concrete inserts of the "spot" type, of physical size small enough to avoid the bottom joist steel. All inserts shall be galvanized. Cast-in-place concrete inserts are preferred over powder-actuated fasteners or expansion anchors, especially in post-tension slab applications. Place cast-in-place anchors prior to concrete pour. For small-bore piping, use Hubbard Enterprises/HOLDRITE #125 series brackets or owner approved equipment.
- E. Fasteners: Fastening of pipes, conduits, and similar items in the building shall be as follows: To wood members - by wood screws; to masonry - by threaded metal inserts, metal expansion screws, or toggle bolts, whichever is appropriate for the particular type of masonry; to steel - machine screws or welding (when specifically permitted or directed), or bolts, and to new concrete by suitable inserts anchored to reinforcing steel, and poured in place unless other means are indicated on the plans. All fasteners shall be cadmium plated or galvanized. **Power-actuated fasteners (shooting) will not be acceptable under any circumstances.**
- F. Piping in Multiple Parallel Runs: Provide galvanized structural channels or angles with Anvil Fig. 137/137 C or equal galvanized U-bolt clamps, supported as trapeze hangers where multiple parallel runs of piping are shown. Coated U-bolts shall be provided for uninsulated glass or copper pipe. Select and size members for weights to be carried and span dimensions between supports.
- G. Piping in Single Runs: Provide Anvil Fig. 260 or equal adjustable clevis hangers with a nut above and below the hanger on the hanger rod. All hangers shall be galvanized.

- H. Copper Pipe Hangers: Hangers supporting and contacting brass or copper lines 3" in size and smaller shall be Anvil Fig. CT 99C or equal, adjustable plastic coated, copper-plated tubing rings. Hangers supporting and contacting brass or copper lines 4" and larger shall be Grinnell Fig. 260 or equal, galvanized, adjustable clevis, with a nut above and below the hanger on the support rod and approved neoprene isolating material between pipe (or tubing) and hanger. For insulated copper or brass domestic water lines, hangers for all sizes of pipe shall be Anvil Fig. 260 or equal, galvanized, adjustable clevis, with a nut above and below the hanger on the support rod and sized to fit the outside diameter of the insulation and hanger. Isolate all copper or brass lines from ferrous metals with approved dielectric materials.
- I. Hanger Rod: Provide cadmium-coated or galvanized hanger rods and nuts of required length. Rods shall be coated or galvanized after threading. Rods shall be cold galvanized after cutting. All hanger rods shall be trimmed neatly so that no more than one inch (1") of excess hanger rod protrudes beyond the hanger nut. In the event a rod is intentionally but temporarily left excessively long (for sloped or insulated lines for example), the Contractor shall take appropriate measures to protect the pipe or other materials from damage. Rod diameters shall be as follows:

<u>Pipe Sizes</u>	<u>Rod Diameter</u>
3/4 - 2"	3/8"
2-1/2 - 3"	1/2"
4 - 5"	5/8"
6"	3/4"
8 - 12"	7/8"
14 - 18"	1"

- J. Riser Clamps: Provide Anvil Fig. 261/261 C or equal galvanized riser clamps with equal bearing on each end. Riser clamps for copper tube shall be plastic coated.
 1. Riser clamps shall be isolated from the structure by use of Hubbard Enterprises Holdrite #274 or #278 riser pad or equal.
- K. Pipe Supports in Chases and Partitions: Horizontal and vertical piping chases and partitions shall be supported by hangers or other suitable support. Pipes serving plumbing fixtures and equipment shall be securely supported near the point where pipes penetrate the finish wall. Supports shall be steel plate, angles or special channels such as Unistrut mounted in vertical or horizontal position. Pipe clamps such as Unistrut P2426, P2008, P1109 or other approved clamps shall be attached to supports. Supports shall be attached to wall or floor construction with clip angles, brackets, or other approved method. Supports may be attached to cast iron pipe with pipe clamp or other approved method. All copper or brass lines shall be isolated from ferrous metals with electrical tape or other dielectric materials to prevent electrolytic action.
- L. Saddles and Shields:
 1. Saddles for Horizontal Insulated Piping Without Vapor Barrier: At each hanger or support on horizontal runs, provide Anvil Fig. 160 or equal black steel saddles, as applicable. Shields as described below may be used instead of the saddles. **[On heating water systems below 140°F (60°C), hangers may be sized for the pipe size and of a material compatible with the pipe. 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 cellular glass or rigid calcium silicate blocking, with jacket of adjacent insulation brought across unbroken, supported on Anvil Fig. 167 or Anvil 260 ISS or equal semicircular galvanized steel 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.
- M. Roller Supports: Provide Anvil Fig. 171/177 or equal adjustable, cast iron pipe roll supports for support of horizontal piping installed in racks, beam supports, suspended and where shown on the Drawings.
- N. 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.

- O. 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 manufacturer's 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.
- P. 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 so piping live and dead loading and stresses from movement will not be transmitted to any pipe or connected 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.
 3. Pipe Slopes: Install hangers and supports to provide the indicated pipe slopes so maximum pipe deflections allowed by ANSI B31 are not exceeded.
- Q. Spacing: Install hangers and supports in piping systems to remove stress from equipment flanges and rotating equipment. The following table gives maximum hanger spacing for copper and steel lines. Hangers shall be more closely spaced where required by the conditions of the installation in order to prevent sagging, excess load on structure and hangers, undue strain on equipment, noise transmission, etc. A hanger shall be placed within 2' of each elbow or tee with a minimum support of one hanger per joint or fitting and at each rise, drop, and trap. Maximum hanger and support spacing shall be as follows and as specified elsewhere:

<u>Trade Pipe Size</u>	<u>Maximum Spacing</u>
1/2"*	5'
3/4"	6'
1" and 1-1/4"	7'
1-1/2"	9'
2"	10'
2-1/2"	11'
3"	12'
4"	14'
5"	16'
6"	17'
8"	19'
10"	22'
12"	23'
14"	25'
16"	27'
18"	28'

* Includes all sizes of cast iron and nonmetallic piping. Cast iron pipe sections exceeding 5 feet in length can be supported on maximum 10 foot centers provided hangers are installed within 18 inches of each joint and fitting. Provide rolled, galvanized sheet metal pipe shields between nonmetallic pipe hangers as required to prevent any visible nonmetallic pipe sag between hangers.

- R. Sway Bracing: Where hanger lengths for cast iron piping exceed 18 inches, sway bracing shall be provided per CISPI recommendations, to prevent pipe shear.

- S. Leveling: Adjust hangers and supports and place grout as required under supports to bring piping to proper levels and elevations.
 - T. Midspan Support: For vertical midspan support of piping 4" and under, use Hubbard Enterprises/Holdrite Stout Brackets TM in conjunction with Hubbard Enterprises/HOLDRITE Stout clamps or two hole pipe clamps (MSS Type 26).
 - U. Vibration Isolation: Refer to Section 230548, "Vibration Isolation", for additional information and support requirements. Pipe hangers made of wood, wire, or sheet iron shall not be permitted.
 - V. 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 25'.
 - 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 30', except that grooved-piping systems shall be supported at each pipe section.
 - 3. Copper tube shall be supported at each story level, but in no case at intervals greater than 25'.
 - 4. Plastic pipe shall be supported at mid point between floors to prevent movement, but in no case at intervals greater than 10'.
 - W. **Tunnel Pipe Racks: All piping in utility tunnels and all stacked piping in pump rooms shall be supported using floor-supported galvanized steel pipe racks. Anchor pads for attaching racks to the tunnel wall, floor and ceiling structure shall be cast in concrete and shall be adequate to properly distribute the rack load. Racks shall be constructed of galvanized channel as manufactured by Unistrut or Superstrut or hot-dip galvanized steel shapes and shall be adjustable for grading of piping.]**
 - X. Finish: All steel and iron hangers on piping including clevis hangers, rods, inserts, clamps, stanchions, brackets, shall be hot dip or electro-galvanized after fabrication for indoor applications and hot dip galvanized after fabrication for exterior applications. Rods shall be electro-galvanized or cadmium plated after threading, for indoor applications and hot dip galvanized after fabrication for outdoor applications. Universal concrete inserts shall be galvanized.
 - Y. Fire Protection Piping Support: Support fire sprinkler and standpipe piping independently of other piping in accordance with NFPA-approved methods and local codes and standards, using UL-listed and labeled support components. Refer to Section 21 12 00 for additional requirements.
 - Z. Secondary Pipe Positioning and Supports: Makeshift, field devised methods of plumbing pipe support, such as with the use of scrap framing materials, are not allowed. Support and positioning of piping shall be by means of engineered methods that comply with IAPMO PS 42-96. These shall be Hubbard Enterprises/HOLDRITE support system or owner approved equipment.
- 3.3 MISCELLANEOUS STEEL:
- A. All miscellaneous steel members, angles, rods, supports, and similar items specified or required for this project shall be galvanized for indoor use or hot dipped galvanized for exterior use and where exposed to ambient conditions. All required miscellaneous steel shall be provided by this Division..
- 3.4 SLEEVES:
- A. General: Provide sleeves around all piping passing through masonry, CMU and concrete walls and partitions, suspended slabs, plaster or dry wall ceilings, structural members, other building features and where shown on the drawings. No sleeves shall be installed through any concrete beam or other deep projections without written approval of the Architect/Engineer.
 - B. Partitions: Sleeves shall be required for piping passing through rated dry wall and plaster partitions. Sleeves shall be set in dry wall mud or plastered in and the pipe passing through the sleeve shall be sealed as outlined in Piping Fire Stops and Seals. Sleeves are not required for piping passing through nonrated dry wall or plaster partitions. Nonisolated piping shall be mudded in and isolated piping shall have the opening mudded to within 1/2" of the pipe and an elastomeric caulk shall be installed in the opening around the pipe or insulation.

- C. Plumbing Storm, Waste and Vent: Sleeves shall not be required for storm, waste or vent piping through slabs on grade or for piping passing through precast structure. Where piping passes vertically through precast structures without sleeving, adequate provisions shall be made to prevent water leakage through slabs where applicable.
- D. Placement: This Contractor shall be responsible for the timely placement of sleeves in construction. If sleeves are not placed during construction, this Contractor shall secure written permission to perform a core drill or cut and patch installation at no cost to the Owner. No piping shall pass through the above obstructions without sleeves, unless noted otherwise.
- E. Sizing: Sleeves shall be one size larger than the pipe passing through the sleeve, except where larger sizes are required for mechanical seals. Where insulated piping passes through construction, sleeves shall be one size larger than the outside diameter of the insulation. All sleeves in floors shall extend 2" above the finished floor. Sleeves through vertical construction shall be minimum 18 gauge galvanized steel. Sleeves through horizontal construction shall be minimum 16 gauge galvanized steel except at pipe riser supports. Sleeves at riser supports for 3" and smaller pipe shall be Schedule 40 galvanized pipe sleeves. Sleeves for riser supports for 4" and larger pipe and for pipe passing through exterior building construction below grade shall be Thunderline Corporation Type WS or an approved equal.
- F. Installation: At no point shall the pipe or its insulation touch the sleeve it passes through. Seal all sleeves which are not in exterior construction below grade or rated construction with an approved non-hardening mastic. Seal sleeves through fire rated construction as specified under "FIRE STOPPING FOR PIPING AND DUCTWORK" and as detailed on the Drawings. Sleeves below grade shall be sealed with segmented annular seal, refer to Paragraph 3.14.
- G. Existing Construction: Sleeves are not required where new openings are core-drilled into existing construction, unless noted otherwise on the Drawings.

3.5 ESCUTCHEON PLATES:

- A. General: Except as otherwise noted, provide chrome-plated brass floor and ceiling escutcheon plates around all pipes, and similar items passing exposed through walls, floors, or ceilings, in any finished spaces except under floor and attic spaces. Plates shall be sized to fit snugly against the outside of the conduit. Plates will not be required for piping where pipe sleeves extend above finished floor. Provide sheet metal trim plates at all penetrations exposed to view of building occupants, unless directed otherwise by the Architect. **[All equipment rooms are classified as finished spaces.]**
- B. Type: Escutcheon plates shall be Dearborn Brass Company, Fig. No. 1149 through 1152.

3.6 EXPOSED PIPING:

- A. General: All exposed piping to plumbing fixtures and connected equipment in finished areas shall be polished chrome plated unless noted otherwise on the drawings. This shall include piping, fittings and valves. Polished chrome plated sleeves may be used over supply, waste and vent piping provided that the finished installation presents the appearance of a fully chrome plated system.

3.7 PIPE CLEANING AND STERILIZATION:

- A. HVAC Piping: All piping shall be cleaned following successful pressure testing of pipe. Piping shall be completely drained following pressure testing and then filled with clear water and pipe cleaning treatment (Mogel C-641 or approved equal) to the suppliers recommended concentration required to rid the system of rust, dirt, piping compound, mill scale, oil, grease, and any other foreign material. The system shall then be circulated per the suppliers recommendations. Following cleaning, each system shall be drained, refilled and then continuously filtered or flushed until clean water is obtained. Strainers shall be removed and cleaned after each flushing. Refer to Section 232500, "HVAC Water Treatment", for water treatment for these systems. After the system has been pressure tested, treated with pipe cleaning treatment and rinsed with clear water to remove the cleaning treatment, a 5 micron in-line filter may be installed in the system, in lieu of continuous water flushing, to clear the piping of construction debris. Each system being filtered shall be pumped continuously and the filter shall be cleaned once every 24 hours until no visible filtered matter is present in the filter after 24 hours of circulation. After the cleaning process is complete, the filters shall be removed from the system and all strainers shall be cleaned prior to putting the piping system into operation. **[Provide temporary loop piping and fill/drain valves as required to allow building piping to be flushed and circulated until the system is clean, prior to making connections to the [complex] [campus]**

utility piping system.] [Piping mains shall be cleaned and flushed (or circulated and filtered) with coil and equipment isolation valves closed, until fully clean. When the mains are fully cleaned, then coil and equipment isolating and control valves shall be opened, air shall be removed from coils via air vents, and the system shall be cleaned and flushed (or circulated and filtered), until fully clean. Temporary loop connections shall be provided as required to circulate all main piping with coil and equipment isolation valves closed.]

- B. Domestic Water Piping: All potable water piping and tanks shall, after successful pressure testing, be thoroughly flushed with clear water and then sterilized. Sterilization shall be with either liquid chlorine or chlorine gas of adequate volume to give a concentration of 50 ppm based upon the volume of the system being treated. A minimum residual chlorine level of 5 ppm shall remain in each system for a minimum of 24 hours. After sterilization, all piping shall be thoroughly flushed. The above are minimum requirements and all sterilization procedures shall be in strict accordance with all local codes and authorities having jurisdiction.

3.8 OPENINGS, CUTTING AND PATCHING:

- A. General: The Contractor shall be responsible for coordinating openings in the building construction for installation of mechanical systems. Coordinate penetrations and place equipment in time to avoid cutting new construction. Comply with the requirements of Division 1 for the cutting and patching of other work to accommodate the installation of mechanical work. Except as individually authorized by the Architect/Engineer, cutting and patching of mechanical work to accommodate the installation of other work is not permitted.
- B. Cut and Patch: Cut and patch walls, floors, and similar items resulting from work in existing construction or by failure to provide proper openings or recesses in new construction.
- C. Methods of Cutting: Openings cut through concrete and masonry shall be made with masonry saws and/or core drills and at such locations acceptable to the Architect/Engineer. Impact-type equipment shall not be used except where specifically acceptable to the Architect/Engineer. Openings in precast concrete slabs for piping and similar items shall be core drilled to exact size.
- D. 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 the Architect/Engineer. Patching shall create a surface which 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.
- E. 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.
- F. Restoration: All openings shall be restored to "as-new" condition under the appropriate Specification Section for the materials involved, and shall match remaining surrounding materials and/or finishes. Restoration work shall be performed by the trades who originally installed the work being restored and shall be performed at no cost to the Owner or Architect/Engineer.
- G. Masonry: Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry. Adequate supports shall be provided during the cutting operation to prevent any damage to the masonry occasioned by the operation. All structural members, supports, and similar items shall be of the proper size and shape, and shall be installed in a manner acceptable to the Architect/Engineer.
- H. Plaster: All electrical work in areas containing plaster shall be completed prior to the application of the finish plaster coat. Cutting of finish plaster coat will not be permitted.

- I. Special Note: No cutting, boring, or excavating which will weaken the structure shall be undertaken.

3.9 EXCAVATION, TRENCHING AND BACKFILL:

- A. General: The work hereunder includes whatever excavating and backfilling is necessary to install the mechanical work. Coordinate the mechanical work with other work in the same area, including excavating and backfilling, dewatering, floor protection provisions, other temporary facilities, other underground services (existing and new), landscape development, paving, structural foundations, and

- floor slabs on grade. Coordinate with weather conditions and provide temporary facilities needed for protection and proper performance of excavating and backfilling.
- B. Standards: Except as otherwise indicated, comply with the applicable provisions of Division 2 for mechanical and plumbing work excavating and backfilling. Refer instances of uncertain applicability to the Architect/Engineer for resolution before proceeding with the Work.
 - C. The bottoms of trenches shall be excavated to required depths, slope and grade. The bottom of the trench shall be accurately excavated to provide firm, uniform bearing for the bottom of the pipe. Where mud or unstable soil is encountered in bottom of trench, it shall be removed to firm bearing and the trench shall be backfilled with bedding sand to proper grade and tamped to provide uniform firm support.
 - D. The bottom of trenches shall be accurately graded to provide proper fall and uniform bearing and support for each section of the pipe on undisturbed soil or 2" of sand fill at every point along its entire length.
 - E. Exercise care not to excavate below required depth, leaving a flat bed of undisturbed earth, firm and secure, before laying pipe. In the event rock is encountered, excavate 6" below required depth and backfill to required depth with bedding sand, and compact to minimum 95% compaction.
 - F. All grading in the vicinity of excavation shall be controlled to prevent surface ground water from flowing into the excavations. Any water accumulated in the excavations shall be removed by pumping or other acceptable method. During excavation, material suitable for backfilling shall be stacked in an orderly manner a sufficient distance back from edges of trenches to avoid overloading and prevent slides or cave-ins. Material unsuitable for backfilling shall be wasted and removed from the site and properly disposed of.
 - G. The Contractor shall be fully responsible for the safety of persons, materials and equipment in or near trenches or other excavations and provide all required sloping, shoring, railings and other protective provisions. The Contractor shall provide a trench shoring plan and design which is sealed by a registered professional engineer. Refer to Divisions 1 and 2 for additional requirements.
 - H. If any unknown and/or uncharted utilities are encountered during excavation, promptly notify Architect/Engineer and wait for his instructions before proceeding.
 - I. If such unknown utilities are encountered and work is continued without contacting the Architect/Engineer for instructions, and damage is caused to said utilities, the Contractor shall repair at his own expense, such damage to the satisfaction of the Owner or utility company concerned.
 - J. Trenches shall not be backfilled until all required tests have been made by the Contractor and approved by the Architect/Engineer and any local authorities having jurisdiction.
 - K. Backfill shall be compacted or cement stabilized sand up to 6" above the top of piping. Backfill up to grade shall be in maximum 6" lifts with minimum 95% compaction of lifts. Refer to Division 2 or elsewhere in Contract Documents for additional trenching and backfill requirements.
 - L. Opening and Reclosing Pavement, Landscape Areas, and Lawns: Where excavation requires the opening of existing walks, street, drives, other existing pavement or lawns, such surfaces shall be cut as required to install new piping and to make new connections to existing piping. The sizes of the cut shall be held to a minimum, consistent with the work to be accomplished. After the installation of the new work is completed and the excavation has been backfilled and flooded, the area shall be patched or replaced, using materials to match those cut out or removed. Patches shall thoroughly bond with the original surfaces, shall be level with them, and shall meet all the requirements established by the authorities having jurisdiction over such areas. All removed work shall be replaced by craftsman who regularly install the types of work being replaced.
 - M. Excavation in Vicinity of Trees: All trees including low hanging limbs within the immediate area of construction shall be adequately protected to a height of at least 5'to prevent damage from the construction operations and/or equipment. All excavation within the outermost limb radius of all trees shall be accomplished with extreme care. All roots located within this outermost limb radius shall be brought to the attention of the Architect before they are cut or damaged in any way. The Architect will give immediate instructions for the disposition of same. All stumps and roots encountered in the excavation, which are not within the outermost limb radius of existing trees, shall be cut back to a distance of not less than 18" from the outside of any concrete structure or pipeline. No chips, parts of

stumps, or loose rock shall be left in the excavation. Where stumps and roots have been cut out of the excavation, clean compacted dry bank sand shall be backfilled and tamped.

3.10 ACCESS DOORS:

- A. General: This Contractor shall provide wall or ceiling access doors for installation in finished surfaces for unrestricted access to all concealed items of mechanical equipment.
- B. Types: Doors shall be factory-finished as noted below and turned over to the General Contractor for installation, refer to finish painting requirements specified herein below. Doors shall be as manufactured by Inryco/Milcor or an approved equal in the following styles:
 - 1. Drywall Construction Inryco/Milcor Style DW with gray prime finish.
 - 2. Finished Acoustical Ceiling Tile Inryco/Milcor Style AT with door designed for tile insert.
 - 3. Finished Plaster Ceiling or Walls Inryco/Milcor Style WB-PL with door designed for finish plastering.
 - 4. Masonry Walls Inryco/Milcor Style M with gray prime finish.
 - 5. Fire Rated Construction Inryco/Milcor Fire Rated Access Door with gray prime finish.
 - 6. Fire Rated Ceiling or Ceiling Assembly Inryco/Milcor Style ATR with door designed for tile insert.
- C. Selection: Access doors shall be furnished with a continuous piano hinge with screwdriver-operated flush locks and shall be a minimum of 12" x 12". Larger sizes shall be furnished where required for proper access.
- D. Approval: Access doors shall not be installed until location and style have been approved by the Architect.

3.11 FIRESTOPPING FOR PIPING AND DUCTWORK:

- A. General: Provide a UL Systems Classified, intumescent material capable of expanding up to eight to ten times when exposed to temperatures beginning at 250°F for sealing all holes or voids created to extend mechanical system piping, ductwork and other components through fire-rated floors and walls and other fire rated construction to prevent the spread of smoke, fire, toxic gas and water. The fire barrier system shall meet the fire test requirements and hose stream test requirements of ASTM E119-73.
- B. Fire barrier products shall be used to create through-penetration fire stop systems as required, with a minimum fire rating equal to the rating of the construction being penetrated. All fire stop systems shall be listed in the Underwriter's Laboratories Building Materials Directory, Through Penetration Firestop Systems (XHEZ).
- C. The products manufactured by 3M/Electrical Products Division or an approved equal are acceptable subject to Shop Drawing submittal approval.
- D. Install fire stop materials according to the following UL Systems Classifications and manufacturer's recommendations:

<u>OPENING TYPE</u>	<u>UL SYSTEM CLASSIFICATION NUMBER</u>
Metal Pipe Through Round Openings	No. 49, No. 95, and No. 147
Insulated Metal Pipe Through Round Openings	No. 91, No. 147, and No. 64C
Metal Pipe Through Large Openings	No. 93
Blank Openings	No. 92, No. 102, and No. 61
Glass Pipe Through Opening	No. 90b
Plastic Pipe Through Opening	No. 64b and No. 148
All Other Firestop Systems	Per manufacturer's recommendations

- E. Provide fire rated insulation blankets around ductwork and piping where shown on Drawings. Blankets shall be one inch (1"), 8 pound density thermo ceramic material, Thermo Ceramics Kas-Wool Fire Master Series thermal blankets or and approved equal. Blankets shall be wrapped to provide

continuous coverage and be secured with stainless steel bands in accordance with the manufacturer's UL-listed installation instructions.

3.12 FIRE-RATED PARTITIONS:

- A. Coordinate locations of piping in fire-rated partitions so not to effect the fire rating of the partition. Notify the Architect/Engineer in writing where additional construction is required to maintain the partition fire rating.

3.13 FLAME SPREAD PROPERTIES OF MATERIALS:

- A. Materials and adhesives incorporated in this project shall conform to NFPA Standard 255 (1984), "Method of Test of Surface Burning Characteristics of Building Materials". The classification shall not exceed a flame spread rating of 25 for all materials, adhesives, finishes, and similar items specified for each system, and shall not exceed a smoke-developed rating of 50.

3.14 PENETRATIONS, FLASHING, AND SEALS:

- A. Pipe sleeves, pitch pockets, and flashings compatible with the roofing and waterproofing installation shall be provided for all roof and wall penetrations and roof-mounted equipment and supports. Coordinate flashing details with the Architectural details and the roofing/waterproofing Contractors.
- B. Segmented Annular Seals: Seal the openings around piping which penetrate the exterior construction using segmented annular seals to prevent the entry of water and other foreign material. Segmented annular seals shall be Thunderline Corporation Type LS Series link seals or an approved equal. Seals shall be Style C insulating type for standard service at temperatures up to 250°F. Seals shall be Style T high temperature service at temperatures up to 450°F. Sleeves for use with annular seals shall be Thunderline Corporation Type WS or an approved equal.

3.15 CLEANING AND PAINTING OF MECHANICAL WORK:

- A. Prime, protective and touch-up painting is included in the Work of this Division. Finish painting in equipment spaces, concealed locations, and other locations not exposed to the view of building occupants is included in the work of this Division. Finished painting in areas exposed to the view of building occupants is specified under Division 9.
- B. All equipment furnished by the mechanical subcontractor shall be delivered to the job with suitable factory protective finish.
- C. Mechanical equipment with suitable factory-applied finishes shall not be repainted; except for aesthetic reasons where located in finished areas as directed by the Architect and in a color selected by the Architect. Where factory-applied finishes are damaged in transit, storage or installation, or before final acceptance, they shall be restored to factory-fresh condition by competent refinishers using the spray process.
- D. All equipment not finished at the factory shall be given a prime coat and then finish painted with two coats of enamel in a color as directed by the Architect/Engineer. No nameplates on equipment shall be painted, and suitable protection shall be afforded such plates to prevent their being rendered illegible during the painting operations.
- E. All uninsulated black steel piping, hangers, supports, and similar items shall be given two coats of primer. Where exposed to outdoor weather or exposed to view in equipment rooms, uninsulated black steel piping shall be primed and finished with two coats of enamel in colors as directed by the Architect/Engineer.
- F. Concealed fire protection and plumbing piping shall **[not be painted] [be primed, unless insulated.]** Uninsulated plumbing and fire protection piping, where exposed to view in equipment rooms, shall be primed and finished with two coats of enamel in colors as directed by the Architect/Engineer. The fire pumps and all related fire protection piping in **[the fire pump room] [the Central Plant] [and all other mechanical spaces]** shall be primed and finish painted red.
- G. All uninsulated black steel pipe direct buried shall be given two coats of primer and then coated with 3M Scotchwrap Pipe Insulation #50 applied in strict accordance with manufacturer's published recommendations (machine wrapping of pipe is acceptable) prior to burial in the ground.
- H. All insulated piping and equipment in the Central Plant**[, tunnels]** and other mechanical/electrical rooms where exposed to view shall be primed and finish painted with two coats of enamel in colors as

directed by the Architect/Engineer or Owner's Representative; and where concealed in furrings, chases, or suspended ceilings, need not be painted.

- I. All grilles and registers will be furnished with a factory-applied finish. Should the plans indicate that certain grilles and registers be furnished with a factory-applied prime coat for field painting, the cores shall be removed for painting under Division 9. The frames, after installation, shall be given two coats of enamel. The cores shall be spray painted with two coats of enamel, and shall be reinstalled in the frames only after both cores and frames are thoroughly dry. In such cases the color of the enamel finish shall be as directed by the Architect/Engineer.
- J. All equipment in the Central Plant, whether insulated or not, shall be field painted with two coats of suitable enamel in a color as directed by the Architect/Engineer.
- K. The surfaces to be finish-painted shall be prepared as follows:
 - 1. Galvanized and black steel surfaces shall be fully cleaned and painted with one coat of galvanized metal primer.
 - 2. Aluminum surfaces shall first be fully cleaned painted with one coat of zinc chromate primer.
 - 3. Cast iron pipe shall first be fully cleaned and painted with a "nonbleed" primer.
 - 4. Insulated surfaces shall be sized and primed using materials recommended by the insulation manufacturers.
- L. All ferrous metal surfaces without a protective finish and not galvanized in exposed and concealed areas including chases, under floor and above ceilings shall be painted with two coats of zinc chromate primer as the construction progresses to protect against deterioration.
- M. No nameplates on equipment shall be painted, and suitable protection shall be afforded to the plates to prevent their being rendered illegible during the painting operation.
- N. Before painting, all surfaces to be painted shall be suitably prepared. This shall include removing all oil, rust, scale, dirt, and other foreign material. Surfaces shall be made smooth by grinding, filing, brushing, or other approved method. In the painting operations, the primer for metal surfaces shall be of the zinc dust type unless specified otherwise, and where finish painting is specified, it shall be painted using materials and colors selected and approved by the Architect/Engineer. Refer to Division 9 for additional requirements.

3.16 MECHANICAL SYSTEM IDENTIFICATION:

- A. Identification of Equipment:
 - 1. All pieces of major mechanical, plumbing and fire protection equipment shall have a manufacturer's label identifying the manufacturer's address, equipment model and serial numbers, equipment size, and other pertinent data. Care shall be taken not to obliterate this nameplate in any way.
 - 2. The Contractor shall make it possible for the personnel operating and maintaining the equipment and systems in this project to readily identify the various pieces of equipment, controls, devices and similar items by marking them. All items of equipment, controls, devices and similar items shall be clearly marked using engraved nameplates as hereinafter specified. The item of equipment shall indicate the same designation as shown on the Drawings, where applicable.
 - 3. Equipment nameplates shall be three ply laminated plastic, a minimum of 3/32" thick, black-white-black for equipment on normal power, red-white-red for equipment on emergency power, and blue-white-blue for equipment on UPS power. Letters shall be similar to Roman Gothic of a size that is legible (1/2" minimum for description and 3/8" minimum for supplementary text) and appropriate to the application. Attachment of nameplates shall be by stainless steel screws. Rivets or adhesives are not acceptable. **[Nameplates on equipment installed in finished areas shall be installed as directed by the Architect. Verify location with the Engineer.]**

[EDIT TO SUIT PROJECT]

- a. Mechanical, Plumbing and Fire Protection equipment to be identified includes: All chillers, cooling tower cells, boilers, pumps, condensate return units, boiler feed units, blowdown separators, converters, heat exchangers, expansion/compression tanks, control air compressors, air handling units, fan coil units, rooftop units, condensing units, filter

housings, computer room air conditioning units, CPU chillers, dry coolers, HVAC terminal units, fans, water heaters, tanks, water softeners, air compressors, vacuum pumps, control panels, fire dampers, fire/smoke dampers, motorized automatic dampers, and other major pieces of mechanical equipment.

- b. Nameplates on powered equipment shall indicate the source feeding equipment and shall indicate variable speed, time delay operation, firefighter's override operation, etc., where applicable.

Example:

AHU 28
Fed from DPA-3
Room 1.102
Two Speed

- c. Individual controls and pilot lights on controllers and control panels shall have nameplates showing the device function.
 - d. HVAC terminal units shall be identified with a permanently attached engraved name tag, as specified for equipment. In addition, the terminal unit designation shall be clearly marked in 6" high letters on the bottom of the unit using a black felt tipped marker.
- B. **Valves [and Steam Traps]:** Valves **[and steam traps]** shall be marked with 1-1/2" diameter aluminum or engraved plastic tags securely attached to valve stems with "S" hooks.
1. Prepare and install, in a suitable glazed frame, typewritten valve charts giving the number, location and function of each line valve installed under this Contract. Each valve shall be numbered on these charts in accordance with the system of which it is a part of its location. For example, valves in different systems would be designated as follows:
 - a. HPS-1-3 High Pressure Steam - 1st Level - Valve No. 3.
 - b. CHS-2-4 Chilled Water Supply - 2nd Level - Valve No. 4.
 2. Provide and install identification tags lettered and numbered to correspond to the information shown on the charts described above. These tags are to be affixed to only those valves the functions of which are not obvious. For example, it would not be expected that valves at a pressure reducing station in a machine room would be tagged.
 3. Valves at water heaters and steam PRV stations, valves associated with condensate, gas, water meters, and other valves as specified shall also be tagged with standardized color coded plastic tags. These tags shall be 2-1/2" wide by 1-1/2" high with these color codings: red = normally closed; green = normally open; blue = open in winter, closed in summer; and yellow = closed in winter, open in summer. Tags should be engraved on both sides.
- C. **Piping:** Piping at major equipment, in all equipment rooms where exposed, where concealed in accessible locations and where concealed behind access doors or panels shall be color coded as to type of use, service and direction of flow in accordance with the latest edition of ANSI A13.1. Markers shall be located at each valve, at entries through walls and on 20'centers on straight runs of pipe. Piping concealed in accessible locations shall be marked on 50'centers on straight runs of pipe and at all changes in direction. Labels shall have color coded backgrounds with 1/2" to 2" high lettering, depending on pipe size.
1. Markers shall be located on the two lower quarters of the pipe where view is unobstructed.
 2. Use Seton Setmark Type SNA or Brady snap-on type identification for all piping systems, 3/4" through 6". For piping systems larger than 6", use Seton or Brady strap on markers.
 3. Pipe Markers shall conform to ANSI A 13.1-1981 "Scheme for the Identification of Piping Systems". Arrow markers must have same ANSI background colors as their companion pipe markers, or be incorporated into the pipe identification marker.
 4. Pipe markers, zone identification and arrow markers shall be provided on, but not limited to, piping of the following systems:
 - a. Chilled water supply.
 - b. Chilled water return.
 - c. Condenser water supply.

- d. Condenser water return.
 - e. Heating hot water supply.
 - f. Heating hot water return.
 - g. Low pressure steam.
 - h. Medium pressure steam.
 - i. High pressure steam.
 - j. Gravity steam condensate.
 - k. Pumped steam condensate.
 - l. Atmospheric relief.
 - m. Instrument air.
 - n. Domestic cold water supply.
 - o. Industrial cold water supply.
 - p. Domestic hot water supply.
 - q. Domestic hot water return.
 - r. Industrial hot water supply.
 - s. Industrial hot water return.
 - t. Domestic chilled drinking water supply.
 - u. Domestic chilled drinking water return.
 - v. Treated water.
 - w. Sanitary sewer/vent.
 - x. Acid waste/vent.
 - y. Roof/storm drain.
 - z. Laboratory air.
 - aa. Laboratory vacuum.
 - bb. Natural gas.
 - cc. Fire protection.
- D. Underground Pipe Identification: Bury a continuous, preprinted, bright colored plastic ribbon cable marker, Brady No. 91600 Series or an approved equal with each underground pipe (or group of pipes). Locate each directly over piping, 6" to 8" below finished grade. Ribbons shall be detectable from above grade using a pipe locator.
- E. Manufacturers: Acceptable manufacturers are Seton Nameplate Corporation, W.H. Brady Company or Westline Company.
- F. Piping Drawings: Provide a schematic diagram of each piping system **[and mechanical room]**, showing each valve with its tag designation and location. Laminate diagrams and install under framed polycarbonate at locations as directed by the Owner.
- G. Records: Nameplate[, **steam trap**] and valve designation data shall be recorded on record drawings and on itemized listing by equipment types and valve number sequence. Itemized listings shall include designation, device description and device location.
- 3.17 **WARNING SIGNS AND OPERATIONAL TAGS:**
- A. Warning Signs: Provide warning signs where there is hazardous exposure associated with access to or operation of mechanical facilities. Provide text of sufficient clarity and lettering of sufficient size to convey adequate information at each location; mount permanently in an appropriate and effective location. Comply with recognized industry standards for color and design.
 - B. Operational Tags: Where needed for proper and adequate information on operation and maintenance of mechanical systems, provide tags of plasticized card stock, either preprinted or hand printed. Tags shall convey the message, example: "DO NOT OPEN THIS SWITCH WHEN BURNER IS OPERATING".
- 3.18 **PROHIBITED MARKINGS:**
- A. Prohibited Markings: Markings which are intended to identify the manufacturer, vendor, or other source from which the material has been obtained are prohibited for installation within public, tenant, or common areas within the project. Also prohibited are materials or devices which bear evidence that markings or insignias have been removed. Certification, testing (example, Underwriters' Laboratories, Inc.), and approval labels are exceptions to this requirement.

3.19 TAMPER RESISTANT FASTENERS:

- A. All exposed fasteners utilized **[inside psychiatric units]** shall be of a tamper resistant design. All fasteners shall be of the same type whenever possible. Coordinate fastener selection with other trades to provide similar fastener types whenever possible. A minimum of three tools for use with each type of tamper resistant fastener shall be furnished to the Owner at the time of substantial completion.

3.20 EQUIPMENT CONNECTIONS:

- A. Alignment: All piping connecting to pumps and other equipment shall be installed without strain at the piping connection. The Contractor may be required as directed to remove the bolts in these flanged connections or disconnect piping to demonstrate that piping has been so connected.
- B. Connections Different From Those Shown: Where equipment requiring different arrangement or connections from those shown is approved, it shall be the responsibility of the Contractor to install the equipment to operate properly and in harmony with the intent of the Drawings and Specification. When directed by the Architect/Engineer, the Contractor shall submit drawings showing the proposed installation.
- C. Equipment Guards: Provide easily removable expanded metal guards for all belts, couplings, exposed fan inlets and outlets and other moving parts of machinery. Provide access holes to motor and fan shafts on all belt drive and variable speed equipment.
- D. Supports: The Contractor shall support plumb, rigid and true to line all work and equipment furnished under his division. The Contractor shall study thoroughly all Architectural, Structural, Mechanical and Electrical drawings, shop drawings and catalog data to determine how equipment is to be supported, mounted or suspended, and shall provide all bolts, inserts, pipe stands, brackets and accessories for proper support

3.21 ROTATING SHAFTS:

- A. General: Shafts for rotating equipment, such as fans, shall be designed, sized, and fabricated so the shaft will not pass through the first critical speed when accelerating from rest to normal operating speed. This provision shall include the effect of the driven equipment, such as fan blades and related appurtenances, that may influence performance.

3.22 BELT AND COUPLING GUARDS:

- A. General: Provide metal belt guards for all belt-driven equipment. Construct guards sufficiently rigid to provide the required protection and be noise free when the equipment is in operation. Provide coupling guards for all flexible couplings. Coupling guards and belt guards may be perforated metal to allow visual inspection. Belt guards shall have openings to allow measurement of pulley rpm without removal of the guard.
- B. Belt Drives: Belt Drives have been selected as accurately as possible under design conditions. Whenever, in the course of balancing a system, it is determined that a drive change is required, the Contractor shall furnish one completed drive change without additional cost to the Owner or Architect/Engineer. Multiple belt drives shall have matched belt sets.

3.23 BEARINGS:

- A. General: All ball bearings shall be of radial and/or thrust type, and enclosed in a dust and moistureproof housing. All bearings shall be B-10 minimum life 100,000 hour type selected in accordance with AFBM ratings and arranged for lubrication through Alemite fittings. Bearings shall be standard cataloged items and replacement shall be locally stocked.

3.24 EQUIPMENT HOUSEKEEPING PADS AND ANCHOR BOLTS:

- A. Concrete pads for equipment (housekeeping pads) will be furnished under **[another] [this]** Division. Pads shall be provided **[in the central plant and in other]** in locations where floor mounted equipment is to be installed.
- B. Pads shall be **[nominal 6" high in the central plant and]** nominal 3-1/2" high **[in all other locations]** and shall extend a minimum of 3" beyond all equipment and supports while generally conforming to the shape of the equipment. **[Provide pad heights to match existing pads where located in the same room.]**

- C. Pads shall be minimum 2500 psi (28 day) concrete reinforced with No. 6 - 6" x 6" welded wire mesh. Pad tops and sides shall be hard troweled smooth with a 3/4" bull nose on all external corners. Refer to Division 3 for additional requirements.
- D. Furnish galvanized anchor bolts with layout templates for installation in equipment pads. Bolts shall be of the size and quantity recommended by the manufacturer and where vibration isolators are used, they shall be anchor bolted to the equipment pad.

3.25 MISCELLANEOUS CURBS AND SUPPORTS:

- A. General: Where required, curbs and supports shall be of box section design, heavy gauge galvanized steel construction, continuous mitered and welded corner seams, integral base plate, factory installed wood nailer, and shall be insulated with 1-1/2" thick, rigid fiberglass board insulation. Curbs and supports shall be mounted and flashed according to manufacturer's recommendations. Curbs and supports shall be as manufactured by the Pate Company of the style as outlined below or approved equal.
- B. Utility Fan Curbs: Shall be Style PC-1A, 12" high.
- C. Duct Curbs: Where ducts are required to penetrate the roof without passing through an equipment curb, Pate Style PC-1A, 12" high curbs shall be used.
- D. Piping Curbs: Where piping penetrates the roof without passing through an equipment curb, Pate Style PCA-1, 12" high curbs shall be used.
- E. Equipment and Piping Supports: Roof mounted equipment and piping routed across the roof shall be supported using Pate Style ES-1A equipment supports with provisions for securing equipment and piping as required. Equipment curbs shall be 12" high. Piping curb height shall be as required to maintain piping slope.

3.26 DEVICE MOUNTING HEIGHTS:

- A. Refer to architectural drawings to determine whether devices occur in wainscot or cabinet spaces and coordinate mounting heights as required by architectural form. For example, mounting heights of devices occurring in a tile or brick wall should be adjusted so that the device will occur entirely within a single course. However, all devices in a given space shall be mounted at the same height.
- B. In general, unless noted otherwise on Architectural or Mechanical Drawings, mounting heights to device center line shall be as follows **[devices occurring in tile walls shall be shifted, slightly, to allow mounting at the best suitable point in a particular tile]**:

- | | |
|--|---|
| 1. Wall mounted thermostats/temperature sensors | [45"] [48"] [In general, locate thermostats/sensors 6" from room light switches and at the same vertical centerline height as switches] |
| 2. Wall mounted air devices | As noted on Drawings or as directed by the Architect/Engineer |
| 3. Wall hung lavatories | 34" to top of lavatory unless noted otherwise on Drawings |
| 4. Wall hung water closets (Standard rough-in) | 17" to top of toilet seat unless noted otherwise on Drawings |
| 5. Wall hung water closet (Handicapped rough-in) | 17" to top of toilet seat unless noted otherwise on Drawings. Flush valves shall be mounted with the operating handle to the wide side of the toilet stall and no more than 44" above the finished floor. |
| 6. Wall hung urinals | 17" to top of elongated rim on fixture. Flush valve controls shall be a maximum of 44" above the finished floor. |

3.27 DEMOLITION AND WORK WITHIN EXISTING BUILDINGS:

- A. The Contractor shall be responsible for loss or damage to the existing facilities caused by him and his workmen, and shall be responsible for repairing or replacing such loss or damage. The Contractor

shall send proper notices, make necessary arrangements, and perform other services required for the care, protection and in-service maintenance of all mechanical, plumbing and fire protection services for the new and existing facilities. The Contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, removing all such temporary protection upon completion of the work.

- B. The Contractor shall provide temporary or new services to all existing facilities as required to maintain their proper operation when normal services are disrupted as a result of the work being accomplished under this project.
- C. Where existing construction is removed to provide working and extension access to existing utilities, Contractor shall remove doors, piping, air conditioning ductwork and equipment, and similar items to provide this access and shall reinstall same upon completion of work in the areas affected.
- D. Where partitions, walls, floors, or ceilings of existing construction are indicated to be removed and reinstalled, this Contractor shall remove and reinstall, in locations approved by the Architect, all devices required for the operation of the various systems installed in the existing construction.
- E. Outages of services as required by the new installation will be permitted but only at a time approved by the Owner. The Contractor shall allow the Owner 2 weeks advance notice in order to schedule required outages in accordance with Utilities Department Outage Notification policy.
- F. The time allowed for outages will not be during normal working hours unless otherwise approved by the Owner. All costs of outages, including overtime charges, shall be included in the contract amount.
- G. The Contractor shall modify, remove, and/or relocate all materials and items so indicated on the Drawings or required by the installation of new facilities. All removals and/or dismantling shall be conducted in a manner as to produce maximum salvage. Survey the project with the Owners representative before demolition begins and determine all materials which the Owner specifically chooses to have salvaged. Pre-establish with the Owner locations where salvaged materials are to be stored. Salvage materials shall remain the property of the Owner, and shall be delivered to such destination as directed by the Owner. Materials and/or items scheduled for relocation and which are damaged during dismantling or reassembly operations shall be repaired and restored to good operative condition. The Contractor may, at his discretion and upon the approval of the Owner, substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.
- H. All items which are to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The Contractor shall clean and repair and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore to good operative order. All relocations shall be performed by workmen skilled in the work and in accordance with standard practice of the trades involved.
- I. When items scheduled for relocation are found to be in damaged condition before work has been started on dismantling, the Contractor shall call the attention of the Owner to such items and receive further instructions before removal. Items damaged in repositioning operations are the Contractor's responsibility and shall be repaired or replaced by the Contractor as approved by the Owner, at no additional cost to the Owner.
- J. Service lines and piping to items to be removed, salvaged, or relocated shall be removed to points indicated on the Drawings, specified, or acceptable to the Owner. Service lines and wiring not scheduled for reuse shall be removed to the points at which reuse is to be continued or service is to remain. Such services shall be sealed, capped, or otherwise tied-off or disconnected in a safe manner acceptable to the Owner. All disconnections or connections into the existing facilities shall be done in such a manner as to result in minimum interruption of services to adjacent occupied areas. Services to existing areas or facilities which must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner as hereinbefore specified.
- K. During the construction and remodeling, portions of the project shall remain in service. Construction equipment, materials, tools, extension cords, and similar items shall be arranged so as to present minimum hazard or interruption to the occupants of the building.

- L. Certain work during the demolition and alteration phase of construction may require overtime or nighttime shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner's Representative at least 72 hours in advance.
- M. Make every effort to minimize damage to the existing building and the Owner's property. Repair, patch, or replace as required any damaged which might occur as a result of work at the site. Care shall be taken to minimize interference with the Owner's activities during construction. Cooperate with the Owner and other trades in scheduling and performance of the work.
- N. Include in the contract price all rerouting of existing ductwork, piping, air devices, fixtures, and similar items and the reconnecting of existing fixtures and devices as necessitated by field conditions to allow the installation of the new systems. Furnish all temporary ductwork and piping, and similar items as required to maintain service for the existing areas with a minimum of interruption.
- O. All existing air devices materials, equipment and appurtenances not included in the remodel or alteration areas are to remain in place and shall remain in service.
- P. Mechanical equipment and building systems equipment, and similar items which are to remain but which are served by piping that is disturbed by the remodeling work, shall be reconnected in such a manner as to leave it in proper operating condition.
- Q. Existing plumbing fixtures, registers, grilles, and diffusers shown to be removed and indicated to be reused, shall be cleaned, repaired and provided with such new accessories as may be needed for the proper installation in their new locations.
- R. Within the remodeled or alteration areas where existing ceilings are being removed and new ceilings are installed, all existing air devices, other ceiling mounted devices and their appurtenances shall be removed and reinstalled into the new ceiling, unless otherwise shown or specified.
- S. Within the remodeled or alteration areas where existing walls are being removed, all existing fixtures, thermostats, other materials and equipment and their appurtenances shall be removed, where required by the remodel work either shown or specified.
- T. Any salvageable equipment as determined by the Owner, shall be delivered to the Owner, and placed in storage at the location of his choice. All other debris shall be removed from the site immediately.
- U. Equipment, piping or other potential hazards to the working occupants of the building shall not be left overnight outside of the designated working or construction areas.
- V. All existing air handling equipment which is shown as being reused shall have coils cleaned and shall be equipped with new filters by this Contractor.
- W. No portion of the fire protection systems shall be turned off, modified or changed in any way without the express knowledge and written permission of the Owners representative.
- X. Refer to Architectural "Demolition" and "Alteration" plans for actual location of walls, ceilings, and similar items being removed and/or remodeled.
- Y. [Drawings do not fully indicate conditions nor existing obstructions or utilities. Visit the site and examine work to be removed and become familiar with conditions affecting work.]
- Z. **[Asbestos removal, if any is not part of this Contract.]**

END OF SECTION 23 03 00

SECTION 23 04 00 - MOTORS AND CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide motors required for equipment furnished under this Division. All motors shall be factory-installed on equipment whenever possible. Motor controllers will, in general, be provided under Division 26 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. The furnishing Contractor will furnish for installation and connection to Division 26 all starters, controllers and disconnect switches which are furnished with their equipment but not integrally mounted.
 - 2. Division 26 shall furnish, install and connect all starters and disconnect switches which are not provided with the served equipment.
 - 3. Division 26 shall furnish and install all interconnecting wiring, conduit and make all connections ready for operation between motors, starters and control devices, as required by wiring diagrams (on approved shop drawings) provided by the Division furnishing the equipment.
 - 4. Division 26 shall furnish miscellaneous 120 volt control power circuits as required for systems and equipment furnished by other Divisions. These control power circuits shall be furnished by Division 26 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 shall typically not be required.

1.3 QUALITY ASSURANCE:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
 - 1. Baldor.
 - 2. Century/Gould.
 - 3. General Electric.
 - 4. Louis Allis.
 - 5. Reliance.
 - 6. Siemens-Allis.
 - 7. U.S. Motors.
 - 8. Westinghouse.

1.4 SUBMITTALS:

- A. Shop drawing submittals for motorized equipment shall include, but not be limited to, the following information on motors provided with equipment.
 - 1. Manufacturer's name and cutsheets.
 - 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 and results.

PART 2 - PRODUCTS

2.1 ELECTRIC MOTORS:

- A. General: Motor voltages shall be as follows, unless noted or specified otherwise:
 - 1. 3/4 hp and larger - 460 volts, 3-phase, 60 Hz.
 - 2. Smaller than 3/4 hp - 120 volts, 1-phase, 60 Hz.
- B. Motors: All motors 7 ½ and up shall have VSD's with bypass, unless specified otherwise. All motors 60 hp and larger shall be reduced voltage started with wye-delta reduced voltage starters for fire pumps and closed transition autotransformer reduced voltage starters for all other motors, unless noted otherwise. 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 dripproof (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, unless noted or scheduled otherwise), 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. Motors used with variable speed drives shall be designed for variable speed use and shall be fully compatible with the furnished variable speed drives. Refer to other Sections herein and the Electrical Drawings for two-speed motors and motors with reduced voltage starting.
- 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 or field-lubricated type roller or 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. All bearings shall be designed for B-10, 100,000 hour minimum life hours of continuous service.
- 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. Windings: All motors shall have copper windings.
- G. 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.
- H. 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.

- I. Housings: All open motors 10 hp and smaller shall have cast aluminum end bells with steel frames. All open motors 15 hp and larger, all enclosed motors and all motors used with variable speed drives shall have cast iron housings, and premium efficiency ratings.
- J. 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 3-phase motors.
- K. 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.
- L. Energy Efficient Motors: Energy efficient motors shall be provided [for all standard frame motors 5 hp and larger, unless noted otherwise] [where noted or specified]. 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>ODP Efficiency</u>	<u>TEFC Efficiency</u>	<u>Minimum Power Factor</u>
1 to 1-1/2 hp	82%	-	0.77
1-1/2 to 2 hp	84%	-	0.80
3 to 5 hp	86%	89%	0.81
7-1/2 to 15 hp	88%	91%	0.87
20 to 40 hp	92%	93%	0.85
50 to 100 hp	93.5%	95%	0.87

- M. Additional Requirements: Refer to the various equipment Sections of this Division for additional motor requirements.

2.2 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: The Mechanical Contractor shall provide all low-voltage control (or line-voltage control where used as an alternate) and interlock wiring required by the temperature control system, except as otherwise noted or specified. Line-voltage power wiring shall be by the Electrical Contractor.
- C. Local Controls: Pushbuttons with or without pilot lights, hand-off-automatic switches and other scheduled apparatus shall be standard duty type mounted in NEMA enclosures or in cover of starter as specified or scheduled, and shall be furnished by the trade furnishing the starter except as specifically indicated elsewhere. Hand-Off-Automatic switches for equipment which could damage itself if left in the "hand" position (such as sump pumps), shall be spring-returned to "off" from the "hand" position.

PART 3 - EXECUTION

3.1 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, such as patching and refinishing of walls, resulting from inadequate information shall be the responsibility of the Mechanical Contractor.

END OF SECTION 23 04 00

SECTION 23 04 10 – ELECTRONIC VARIABLE SPEED DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: The extent of electronic variable speed drive (VSD) work is as scheduled, shown on the Drawings, as indicated by the requirements of this Section, and as specified elsewhere in these Specifications.
- B. Types: The types of electronic variable speed drives required for the project include, but are not limited to variable frequency motor speed controllers.

1.3 STANDARDS:

- A. Products shall be designed, manufactured, tested, and installed in compliance with the following standards, as applicable:
 - 1. NEMA ICS 2 Industrial Control Devices, Controllers and Assemblies.
 - 2. NEMA KS 1 Enclosed Switches.
- B. Each VSD shall comply with the applicable requirements of the latest standards of ANSI and IEEE-519-1981 5% voltage distortion and line notching category. Computations or computer simulations shall be provided with the submittals to confirm compliance. The VSD manufacturer shall supply all necessary items to comply.
- C. VSD design and construction shall comply with all applicable provisions of the National Electric Code.

THE FOLLOWING FOR 60HP MOTORS OR LARGER

- D. **[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.]**

1.4 QUALITY ASSURANCE:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
 - 1. ABB.
 - 2. Toshiba.
 - 3. Yaskawa.
- B. Products supplied under this section must be of domestic (USA) origin and manufacture.]
- C. UL Standards: Speed Controllers shall conform to all applicable UL Standards and shall be UL-listed.
- D. 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.

1.5 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 23 01 00.

1.6 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 - PRODUCTS

2.1 ELECTRONIC VARIABLE SPEED DRIVES:

- A. General: Provide electronic variable speed drives for control of standard or high-efficiency NEMA Design B induction motors on **[air handling units] [, fans] [and pumps]** where specified herein, scheduled, or shown on the Drawings.
- 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.

THE FOLLOWING FOR MOTORS 60HP OR LARGER

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, 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] [230] [460]** volts ac \pm 10%, 60 Hz, \pm 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-**[460] [208] [230]** 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 which 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 [0-5 volt dc Analog] [0-10 volt dc Analog] [4-20 ma dc Analog] [3-15 psig Pneumatic] [135 Ohm Potentiometer] [5000 Ohm Potentiometer] 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 Lights: Status lights for indications 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 lights to show "Power On", "Zero Speed", and "Drive Enabled" shall be provided. All status lights 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. Status lights shall be red, light-emitting diode type for high visibility and reliability.
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.

THE FOLLOWING FOR 60HP MOTORS OR LARGER

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.
- 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

3.1 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 23 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 23 06 00, "Building Controls] [Division 23]**.

3.2 START-UP/TESTING:

- A. Pre-energization Check: The Division 26 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 26 Contractor shall reconnect phase conductors to motor leads at motor junction box.

3.3 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 2 days of classroom instruction for 4 hours per day 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.

3.4 IDENTIFICATION:

- A. Refer to Section 23 03 00 for painting and 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 23 04 10

SECTION 23 05 48 - VIBRATION ISOLATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide vibration isolation supports for all equipment, piping and ductwork as may be required to prevent transmission of vibration and noise to the building structure. Expected noise levels in various parts of the building shall conform to noise criteria recommendations as set forth in the ASHRAE 1987 HVAC Systems and Applications, Chapter 52, Page 52.4. The lowest of the range of NC criteria curves shall apply. It shall be the Contractors responsibility to select and install vibration isolators which will enable the noise criteria standards to be met to the extent that the noise can be controlled by vibration isolators.

1.3 QUALITY ASSURANCE:

- A. General: Except as otherwise indicated, obtain all vibration isolation materials 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. Acceptable Manufacturers: Provide products complying with these specifications and produced by one of the following:
 - 1. Amber/Booth Company, Inc.
 - 2. Korfund Dynamics Corporation.
 - 3. Mason Industries.
 - 4. Metraflex, Inc.
- D. Manufacturer Certification: Where vibration isolation support units are indicated for a minimum static deflection, provide manufacturer's certification that units have been tested and comply with the indicated requirements.

1.4 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
 - 1. A complete listing of proposed types of isolators for each specified application, including size and deflection information.
 - 2. Selection calculations for all isolators with size, type and deflection noted.
 - 3. Vertical isolation riser diagrams with expansion/contraction calculations.
 - 4. Cut sheets for each isolator type to be utilized on the project.
 - 5. A clearly outlined procedure for installing and adjusting all isolators.
 - 6. Cut sheets on all furnished bases and frames.
 - 7. Cut sheets on all flexible connectors and application data as required.
 - 8. Additional information as specified in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver vibration isolation materials in factory-fabricated water-resistant wrapping.
- B. Handle vibration isolation materials carefully to avoid damage to material component, enclosure and finish.
- C. Store vibration isolation materials in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 TECHNICAL REQUIREMENTS:

- A. Deflections indicated are minimums and it shall be the responsibility of the isolation manufacturer to determine the amount of spring deflection required for each isolator to achieve optimum performance, prevent the transmission of objectionable vibration and meet the noise criteria referenced herein.
- B. Spring type vibration isolators shall be used for all equipment driven by motors of 3 hp and larger, unless otherwise noted. Equipment driven by motors 2 hp and smaller shall be isolated by means of elastomeric mounts or hangers properly sized for 1/2" deflection, unless noted otherwise.
- C. All spring isolators shall be completely stable in operation and shall be designed for not less than 30% reserve deflection beyond actual operating conditions. Spring isolators shall be horizontally stable and designed for a minimum k_x/k_y ratio (horizontal to vertical spring rate) of 1.2 times the static deflection (in inches) divided by the working height (in inches).
- D. All elastomeric isolators and isolator components shall be of neoprene or high quality synthetic rubber with antioxidant additives and shall be sized for a maximum load of 60 psi and a rating of 40 durometers.
- E. All vibration isolators and bases furnished by the Contractor shall be designed for and treated for resistance to corrosion. Steel components shall be cleaned and painted with industrial grade enamel. All nuts, bolts, and washers shall be zinc-electroplated. Structural steel bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer. A finish coat of industrial grade enamel shall be applied over the primer.
- F. All isolators exposed to the weather shall have steel parts PVC coated, hot dipped galvanized or be of stainless steel. Aluminum components [shall be etched and painted with industrial grade enamel.]
- G. Isolators for equipment installed outdoors shall be designed to provide adequate restraint due to normal wind conditions and to withstand wind loads of 50 pounds/square foot applied to any exposed surface of the isolated equipment. Where isolators do not meet this requirements, stainless steel tie down cables shall be provided.
- H. Equipment subjected to excessive horizontal air thrust shall be furnished with isolated thrust resisters to limit displacement to 1/4".
- I. Where height-saving brackets for side mounting of isolators are required, the height-saving brackets shall be designed to provide for an operating clearance of 2" under the isolated structure, and designed so that the isolators can be installed and removed when the operating clearance is 2" or less. When used with spring isolators having a deflection of 2-1/2" or more, the height-saving brackets shall be of the pre-compression type to limit exposed bolt length between the top of the isolator and the underneath side of the bracket.
- J. Required spring deflections for isolators supporting various items of equipment are shown on the Drawings or tabulated elsewhere in these specifications, but in no case shall be less than one inch. The springs shall be capable of 30% over-travel before becoming solid.
- K. All isolators supporting a given piece of equipment shall limit the length of the exposed adjustment bolt between the top and base to a maximum range of 1" to 2".
- L. All isolators supporting a given piece of equipment shall be selected for approximately equal spring deflection.

2.2 ISOLATOR TYPES:

- A. General: Isolator types shall be one or more of the following as listed under Paragraph 2.04, "Equipment Isolation". Model numbers of Amber/Booth products are included for identification. Products of other specified manufacturers are acceptable provided they comply with all of the requirements of the specification.
- B. Floor Mounts:
 - 1. Type SW: An adjustable, free-standing, open-spring mounting with combination leveling and equipment fastening bolt. The spring shall be welded to the spring mounting base plate and compression plate for stability. The isolator shall be designed for a minimum k_x/k_y (horizontal-

- to-vertical spring rate) of 1.2 times the static deflection (in inches) divided by the working height (in inches). An elastomeric pad having a minimum thickness of 1/4" and sized for a maximum load of 60 psi with a rating of 40 durometers shall be bonded to the base plate. Nuts, adjusting bolts and washers shall be zinc-electroplated to prevent corrosion.
2. Type RSW: An adjustable, free-standing, enclosed spring mounting for integral mounting in a Type CPF base. The isolator shall be designed for a minimum k_x/k_y (horizontal-to-vertical spring rate) of 1.2 times the static deflection (in inches) divided by the working height (in inches). An elastomeric pad having a minimum thickness of 1/4" and sized for a maximum load of 60 psi with a rating of 40 durometers shall be bonded to the spring base plate. Nuts, bolts and washers shall be zinc electroplated to prevent corrosion. Isolators shall have a steel semihousing with built-in height saving bracket for recessing into a concrete pouring form (CPF) concrete inertia block for side access. Brackets for use with isolators having 2.5 deflection or greater shall be of the precompression type to limit exposed bolt length.
 3. Type XL: An aluminum-housed, adjustable spring mounting having telescoping top and bottom sections separated by resilient elastomeric inserts to limit horizontal motion. Steel or cast iron housings may be used if they are hot-dip galvanized after fabrication. The isolator shall be designed for a minimum k_x/k_y (horizontal-to-vertical spring rate) of 1.2 times the static deflection (in inches) divided by the working height (in inches). An elastomeric pad having a minimum thickness of 1/4" and sized for a maximum load of 60 psi with a rating of 40 durometers shall be bonded to the base plate. Nuts, adjusting bolts, and washers shall be zinc-electroplated to prevent corrosion.
 4. Type RVD: An elastomeric mounting having a steel base plate with mounting holes and a threaded insert at top of the mounting for attaching equipment. All metal parts shall be completely embedded in the elastomeric material. Mountings shall be designed for approximately 1/2" deflection.
 5. Type SP-NRE: A pad type mounting consisting of two layers of 3/8" thick ribbed or waffled elastomeric pads bonded to a 16 gauge galvanized steel separator plate. Pads shall be sized for approximately 20 to 40 psi load and a deflection of 0.12" to 0.16".
 6. Type CT: An adjustable, open-spring isolator having one or more coil springs attached to the top compression plate and a base plate. The isolator shall be designed for a minimum k_x/k_y (horizontal-to-vertical spring rate) of 1.2 times the static deflection (in inches) divided by the working height (in inches). An elastomeric pad having a minimum thickness of 1/4" and sized for a maximum load of 60 psi with a rating of 40 durometers shall be bonded to the base plate. Nuts, adjusting bolts and washers shall be zinc-electroplated to prevent corrosion. The spring assembly shall be removable and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolated restraining bolts which shall not be engaged during normal operation shall connect the top plate and lower housing to prevent the isolated equipment from rising when drained of water.
 7. Type TRK: A set (two or more) of spring thrust resisting assemblies each consisting of a coil spring, spring retainer, isolation washer, steel washer, angle mounting brackets, and neoprene tubing for isolating thrust resister rod at fan discharge or suction.

C. Hangers:

1. Type BS: A spring hanger consisting of a rectangular steel box capable of 200% minimum overload without visible deformation, coil spring, spring retainers, neoprene impregnated fabric washer and steel washer.
2. Type BSR: A combination spring and elastomeric hanger consisting of a rectangular steel box capable of 200% minimum overload without visible deformation, one inch (1") deflection coil spring, spring retainers and elastomeric mounting designed for approximately 1/2" deflection, 1-1/2" total deflection.
3. Type PBS: A spring hanger consisting of a rectangular steel box capable of 200% minimum overload without visible deformation with the addition of a load transfer plate to hold the equipment or piping at a fixed elevation during installation and to permit transferring the load to

the spring after installation, a coil spring, spring retainers, neoprene impregnated fabric washer and steel washer.

4. Type PBSR: A combination spring and elastomeric hanger consisting of a rectangular steel box capable of 200% minimum overload without visible deformation, with the addition of a load transfer plate to hold the equipment or piping at a fixed elevation during installation and to permit transferring the load to the spring after installation, a 2" deflection coil spring, spring retainers and elastomeric mounting designed for approximately 1/2" deflection, 2-1/2" total deflection.
5. Type BRD: An elastomeric hanger consisting of a rectangular steel box capable of 200% minimum overload without visible deformation and an elastomeric isolation element. The elements shall be designed for approximately 1/2" deflection.

D. Base Types:

1. Type HKP: A concrete equipment housekeeping pad as specified in Section 230300, "Basic Materials and Methods".
2. Type CPF: A concrete inertia base, consisting of perimeter steel concrete pouring form (CPF), with reinforcing bars and isolators welded in place. The perimeter steel members shall have a minimum depth of 1/12 of the longest span, but not less than 6" deep. The base shall be sized with a minimum overlap of 4" around the base of the equipment and, in the case of belt-driven equipment, 4" beyond the end of the drive shaft. Fan bases are to be supplied with NEMA standard motor slide rails. The bases for pumps shall be sized to support the suction elbow of end suction pumps and both the suction and discharge elbows of horizontal split-case pumps. The bases shall be T-shaped where necessary to conserve space. The CPF base shall be installed over a concrete equipment (housekeeping) pad as specified elsewhere in Division 23.
3. Type RTIR: An extended aluminum rail base for rooftop air conditioning units consisting of a pair of weatherproofed aluminum rails for fastening to equipment and to the roof curb incorporating wind restraints and a continuous air and water seal which is protected from accidental puncture and direct sunlight by an aluminum weather shield. Rails shall incorporate nonadjustable Type SW spring isolators properly spaced around perimeter and sized for one inch (1") deflection. To prevent leaks, rails shall be factory-assembled (to the limits of freight carriers) and shipped as a one-piece unit.
4. Type SR: A set (two or more) of structural steel channel or angle rails to which isolators are rigidly attached. Bolt holes shall be provided for bolting equipment to the rails. Isolators shall be spaced along the rails on sufficiently close centers to limit deflection of the rail to 1/360 of the unsupported span. Isolators shall be Type SW with vertical limit stops or Type RVD as specified.
5. Type CURB - An equipment roof curb as specified in Section 23 03 00.

2.3 FLEXIBLE PIPE CONNECTIONS:

- A. General: Provide full line size flexible connectors at the suction and discharge connection to each **[chilled water and heating hot water pump]** to each **[domestic water]** pumping system **[in the Central Plant]**, on connections to air compressors**[, vacuum pumps]** and at other locations as shown on the Drawings. All connectors shall be suitable for use at the pressure and temperature encountered at point of operation. End fitting of connectors shall conform to pipe fitting types specified elsewhere.

B. Water Service:

1. Flanged (2-1/2" and Larger), Amber/Booth Type 2800 - a flanged spherical arch rubber expansion joint constructed of molded reinforced neoprene with integral steel floating flanges, suitable for pressures up to 220 psi (4 to 1 safety factor) and temperatures up to **[220°F]**. Connectors shall have minimum movement capability of compression, 1/2" lateral and 15 degrees angular. Spring loaded control units shall be furnished for sizes up through 8" to limit thrust elongation to 3/8". For 10" and larger the control rods shall be fitted with neoprene bushings for isolation.
2. Threaded (2" and Smaller), Amber/Booth Type 2655 - a double spherical rubber hose connector, minimum 8" long, constructed of molded neoprene, nylon cord reinforced, with female pipe

unions at each end. Connectors shall have a minimum movement capability of 7/8" compression, 7/8" lateral, 1/4" extension and 45 degrees angular. Connectors shall be suitable for a maximum working pressure (4 to 1 safety factor) of 150 psi and 220°F.

3. **Grooved, Victaulic Style 77 Coupling: Use at least three couplings in series between vibration source and piping main headers, for vibration isolation. Use more than three couplings if necessary to obtain required total minimum movement. Install per Victaulic Publication TS-5000.]**

C. Steam and Condensate Service:

1. Flanged (2-1/2" and Larger), Amber/Booth Type SS-FP - a flanged metal hose connector constructed of stainless steel hose and braid with carbon steel plate flanges. Minimum lengths shall conform to the following table:

4" and smaller	9" long
5" and 6" diameter	11" long
8" diameter	12" long
10" diameter	13" long
2. Threaded (2" and smaller), Amber/Booth Type SS-PM - a metal hose connection constructed of stainless steel hose and braid with carbon steel NPT threaded end fittings. Minimum lengths shall conform to the following:
 - a. 1-1/2" diameter (and smaller) x 10" long.
 - b. 2" x 12" long.
 - c. 2-1/2" x 13" long.

D. Air Compressor [and Vacuum Pump] Service:

1. Flanged, Type SS-FP (Special): A flanged metal hose connector constructed of stainless steel hose and braid with carbon steel plate flanges. Connector shall be double braided with a minimum live length equal to four times the diameter. Connector shall be installed with the long axis perpendicular to the motion to be absorbed.
2. Threaded, Type SS-PM (Special): A metal hose connector constructed of stainless steel hose and braid with carbon steel NPT threaded end fittings. Connector shall be double braided and have a minimum live length equal to four times the diameter. Connector shall be installed with the long axis perpendicular to the motion to be absorbed.

2.4 EQUIPMENT ISOLATION:

[verify requirements refer to chart in GUIDE spec book]

<u>ISOLATOR EQUIPMENT</u>	<u>MINIMUM TYPE</u>	<u>BASE DEFLECTION</u>	<u>TYPE</u>
Air Handling Units [*]			
Floor Mounted:			
Up to 15 hp	[SW] [XL]	[2.0] [1.0]	HKP
20 hp & Over	[SW] [XL]	[2.5] [2.0]	HKP
Suspended:			
Up to 15 hp	[PBSR] [BSR]	[2.0] [1.5]	----
20 hp & Over	PBSR	[2.5] [2.0]	----
Roof Mounted:	SW	1.0	RTIR
Fan Coil Units [and fan-powered HVAC Terminal units] (Suspended)			
	BRD	0.5	----

Ceiling Mounted A/C Units	BRD	0.5	----
Electronic Air Cleaners	BRD	0.5	----
Fans			
Centrifugal - Floor Mounted			
Up to 15 hp	[RSW] [SW]	[2.5] [1.5]	HKP
20 hp & Over	[RSW] [SW]	2.5	CPF/HKP
Centrifugal - Suspended			
Up to 15 hp	[PBSR] [BSR]	[2.0] [1.5]	----
20 hp & Over	PBSR	[2.5] [2.0]	----
Axial Flow - Floor Mounted			
Up to 15 hp	[SW] [XL]	[1.5] [1.0]	HKP
20 hp & Over	[RSW] [SW]	[3.5] [2.0]	HKP
Axial Flow - Suspended			
Up to 15 hp	[PBSR] [BSR]	[1.5] [1.0]	----
20 hp & Over	PBSR	[2.5] [2.0]	----
Roof Mounted Fans	Isolators furnished with equipment		
In-line Pumps	None	----	----
Floor Mounted HVAC Pumps**			
Up to 5 hp	----	----	HKP
7-1/2 hp & Over	----	----	HKP
Packaged Domestic Water Pumping System	SP-NRE	0.15	HKP
Floor Mounted HVAC Pumps***			
Up to 5 hp	RSW	1.0	CPF/HKP
7-1/2 hp & Over	RSW	[2.0] [1.5]	CPF/HKP
Floor Mounted Plumbing [and Fire Protection] Pumps	None	----	HKP
Air Compressors	RSW****	1.5	HKP
Air Dryer(s)	SP-NRE	0.15	HKP
[Medical] [Laboratory] Air Compressor(s)	SP-NRE	0.15	HKP
[Medical] [Laboratory] Vacuum Pump(s)	SP-NRE	0.15	HKP
Refrigeration Units			
Hermetic Centrifugals	SP-NRE	0.15	HKP
Reciprocating Centrifugals	SP-NRE	0.15	HKP
Boilers	----	----	HKP
Cooling Towers			

Up to 500 Tons	CT	3.0	[Structural Steel Base by G.C. Refer to Structural Drawings.]
Over 500 Tons	CT	4.5	

Air Cooled Condensing Units

Roof Mounted			
Up to 5 Tons	SP-NRE	0.15	CURB
7-1/2 Tons to 20 Tons	CT	1.0	CURB

Computer Room A/C Units ----- Direct mount with neoprene gasket

Water Heaters ----- HKP

- * SP-NRE with 0.15" deflection for internally isolated air handling units in the mechanical rooms.
- ** For pumps installed in the Central Plant.
- *** For pumps installed in the Mechanical Penthouse.
- **** SP-NRE with 0.15" deflection for air compressors installed in the Central Plant.

2.5 PIPING ISOLATION:

[Select one of the following]

A. **General:** All pumped water and refrigerant piping 1-1/2" and larger within mechanical equipment rooms and 2" and larger outside mechanical equipment rooms shall be isolated by means of spring type vibration isolation hangers or floor mounts as may be required to create the effect of a completely floating system. Steam piping 1-1/2" and larger connected to isolated equipment shall be isolated for a distance of 50'. Isolators for equipment are described elsewhere in this specification. It shall be the responsibility of the vibration isolation manufacturer to coordinate the selection of piping supports with equipment supports to provide for a carefully engineered isolation system designed to accommodate expansion and contraction while isolating and supporting the pipe and equipment.]

[or]

B. **General:** Isolate all pumped water, steam condensate and refrigerant piping 1-1/2" and larger within each mechanical equipment room, and for a distance of not less than 50' from motor driven equipment to which the piping is connected. Use type PBS isolators for the first two hangers adjacent to isolated equipment and for all piping 8" and larger. Use Type BS isolators for all other hangers. Floor supported piping shall be isolated with Type SW isolators. The first two isolators adjacent to equipment shall have a deflection equal to the equipment isolation, but not to exceed 2.0"; the remaining isolators shall be sized for 3/4" deflection. Install full line size flexible pipe connectors at the suction and discharge connection of each pump and at the inlet and outlet of each condenser and chiller.]

C. **Riser Diagrams:** The vibration isolation manufacturer shall prepare and submit riser diagrams for approval. These diagrams shall show anticipated vertical expansion and contraction of various segments of the piping and spring deflection changes. Wall sleeves for take-offs from risers shall be sized for insulation O.D. plus two times these anticipated movements to prevent binding. If flexible connectors or expansion loops to relieve stress are required in the riser system, they shall be furnished whether shown or not at no expense to the Owner or Engineer. Type and design shall be submitted to the Engineer for approval. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the design proposed when installed in accordance with submittals and these specifications.

D. Diesel engine exhaust piping and mufflers shall be isolated using spring isolators sized for twice the calculated system expansion.

E. Condenser water system shall be rigidly supported with flexible connections as shown.

- F. Steam and steam condensate piping shall be rigidly supported on roller supports with rigid anchors to structure where shown or required.
- G. All horizontal runs of refrigerant piping 1-1/4" and smaller within the building shall be suspended using Amber/Booth Type HRD-1-A or approved equal rubber-in-shear isolators to prevent compressor noise from being transmitted to the building construction.]
- H. Domestic water[, laboratory gas piping] [,medical gas piping] and fire protection systems shall be rigidly supported with flexible connections as shown or specified.]
- I. Expansion loops and flexible connectors shown on the plans may be omitted provided analysis shows that the piping and equipment connections are not overstressed by their removal. Calculations showing the resultant stress shall be submitted to the Engineer for approval prior to omission of loops and connectors.
- J. Technical Requirements:
 - 1. Hangers for horizontal piping shall be installed at regular intervals as specified in Section 230300, "Basic Materials and Methods". Isolated pipe risers up to 16" shall be supported at intervals of every third floor of the building and every second floor for risers 18" and larger.
 - 2. The first two piping supports away from any given piece of equipment to which piping is connected shall be selected for an operating spring deflection equal to that specified for the equipment isolators, but not to exceed 2". All other supports for horizontal piping shall have a minimum operating deflection of 3/4" with capability of 50% additional travel-to-solid. To prevent excessive transfer of piping load from floor to floor, all riser support springs shall have a deflection capability of four times the expansion or contraction to be accommodated by the support with the additional run-out capability to absorb the movement.
 - 3. **Provide Amber/Booth Type 301 or equal acoustic seals where isolated piping passes through nonfire rated wall, ceiling or floor openings from equipment rooms into adjoining occupied spaces and for all piping in [_____, _____, and _____]. The acoustic seals shall consist of an S-shaped molded synthetic rubber seal attached with stainless steel clamps to the pipe wall sleeves and to carrier piping. The wall sleeves shall be two pipe sizes larger than the insulated carrier piping.**
- K. Isolator Types: Piping system vibration isolators shall be as follows:
 - 1. Type PBS for first two hangers in horizontal piping adjacent to isolated equipment and for all hangers on 8" and larger pipe, except the first two hanger points adjacent to riser shall be Type BS.
 - 2. Type BS for remaining hangers in horizontal piping.
 - 3. Type SW for pipe risers. Isolator base plates shall be provided with holes for bolting and isolation grommets.
 - 4. Type SW for floor supports except Type CT for first floor support adjacent to equipment isolated on CT isolators.

2.6 DUCTWORK ISOLATION:

- A. General: [Rigidly support all ductwork with flexible duct connections at equipment.] [Isolate all high pressure ductwork within each equipment room and to a minimum of 50' from fan with Type BS hangers or SW floor supports, properly sized for 3/4" deflection.]

PART 3 - EXECUTION

3.1 PERFORMANCE OF ISOLATORS:

- 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 noncritical locations, for the selection and application of vibration isolation materials and units as indicated.
- B. Manufacturer's Recommendations: Except as otherwise indicated, comply with manufacturer's instructions for selection and application of vibration isolation materials and units.

3.2 INSTALLATION:

- A. General: Except as otherwise indicated, comply with manufacturer's instructions for the installation and load application of vibration isolation materials and units. Adjust to ensure that units do not exceed rated operating deflections, do not bottom out under loading, and are not short circuited by other contacts or bearing points. Remove space blocks and similar devices (if any) intended for temporary protection against overloading during installation.
- B. Secure Attachment: Anchor and attach units to substrate and equipment for secure operation, to prevent displacement by normal forces.
- C. Adjustment: Adjust leveling devices to distribute loading uniformly onto isolators. Shim units where leveling devices cannot be used to distribute loading properly.
- D. Base Frames: Install inertia base frames on isolator units so a 2" (minimum) clearance below base will result when frame is filled with concrete and supported equipment has been installed and loaded for operation.
- E. Isolation Hangers: Locate isolation hangers as near the overhead support structure as possible.
- F. Welding: Weld riser isolator units in place to prevent displacement from loading and operations.
- G. Airtight Connections: Bond flanges of flexible duct connectors to ducts and housings to provide airtight connections. Seal seams and penetrations to prevent air leakage.

3.3 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 copy to the Engineer, listing observed inadequacies for proper operation and performance of vibration isolation work. Report shall cover, but not necessarily be limited to, the following:
 - 1. Equipment installation (performed as work of other Sections) on vibration isolators.
 - 2. Piping connections including flexible connections.
 - 3. Ductwork connections including provisions for flexible connections.
 - 4. Passage of piping which is to be isolated through walls and floors.
- B. Correction and Start-up: Do not start up equipment until inadequacies have been corrected in a manner acceptable to the vibration isolation installer.

3.4 DEFLECTION MEASUREMENTS:

- A. Report: Upon completion of vibration isolation work, prepare report showing measured equipment deflections for each major item of equipment as indicated. Submit all reports to the Engineer for final review.

3.5 FIELD SERVICES:

- A. Representative: The isolation materials manufacturer shall provide the services of an authorized representative to supervise and ensure correct installation of isolators and sound attenuation materials and proper adjustment of the isolators after installation. Upon completion of the installation and after the system is put into operation and before acceptance by the Owner, the **[authorized manufacturers representative] [Contractor shall provide the services of a qualified Vibration/Noise Consultant who]** shall make a final inspection and submit his report to the Architects and Engineers, in writing, certifying the correctness of the vibration isolation installation and compliance with approved submittal data. Any discrepancies or maladjustments found shall be so noted in the report and shall be corrected by the Contractor and accepted in writing by the **[authorized manufacturers representative] [Contractor's qualified Vibration/Noise Consultant]**. Should any noise or vibration be objectionable to the Owner, Architect or Engineer, the **[Contractor shall provide the services of a qualified] [Contractor's qualified] Vibration/Noise Consultant** shall provide a field instrumentation test and at no cost to the Owner or Architect/Engineer. Any variation or noncompliance with these specification requirements is to be corrected by the installing contractor in an approved manner.

3.6 EQUAL LOADING:

- A. General: All equipment installed on vibration isolation mountings shall be level after load is applied. Further, vibration isolation mountings shall be selected and installed to compensate for unequal

loading. Spring isolators with coils touching during equipment start up or operation will not be acceptable.

END OF SECTION 23 05 48

SECTION 23 05 93 - TESTING, ADJUSTMENT AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. General: All HVAC, plumbing and fire protection systems and equipment on this project shall be successfully proof, acceptance and operationally tested and balanced, as applicable prior to acceptance of the project by the Owner.
- B. Proof and Acceptance Testing: The Division 23 Contractor shall provide proof and acceptance testing of HVAC, plumbing and fire protection systems and equipment during the construction process to verify that systems are installed and function as specified. Piping systems shall not be insulated, covered up, or placed in service until piping has been successfully tested, flushed, cleaned and water-treated, as applicable. Ductwork shall not be externally insulated, covered up or placed in service until it has been successfully tested. Equipment shall not be placed in service until it has been checked out, tested and adjusted, as applicable. The Division 23 Contractor shall provide all required proof and acceptance testing, as specified hereinbelow.
- C. System Adjustments/Operational Certification: The Division 23 Contractor shall provide required system adjustments and certify that each HVAC, plumbing and fire protection system is operational, as specified hereinbelow.
- D. Operational Testing and Balancing: All new **[and modified existing]** HVAC air, **[water]** and control systems on the project shall be operationally tested and balanced prior to acceptance by the Owner. Systems shall be made operational and prepared for operational testing and balancing by the Division 23 Contractor. Operational testing and balancing is specified in Section 230593 and shall be provided by an independent Testing and Balancing (TAB) Consultant who shall be contracted directly to and paid by **[the Owner and shall have no contractual relationship or obligation to the General Contractor or Division 23 Contractor] [the General Contractor] [the Division 23 Contractor]** . The Owner will provide the services of designated Owner's Representatives (OR) who will observe selected testing and balancing for the systems installed on the project. The Division 23 Contractor shall provide coordination with and preparations for the TAB Consultant's operational testing and balancing work as specified hereinbelow.
- E. Project Completion: The Division 23 contractor shall provide project completion services as specified hereinbelow.

1.3 QUALITY ASSURANCE:

- A. References: Comply with applicable requirements and recommendations of the following:
 - 1. AABC - 1989 Fifth Edition: National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems.
 - 2. NEBB - Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.
 - 3. ASHRAE - 1991 HVAC Applications Handbook: Chapter 34, Testing, Adjusting and Balancing.
 - 4. SMACNA - HVAC SYSTEMS Testing, Adjusting and Balancing.
- B. Personnel: Submit evidence to show that the personnel who will actually test systems and equipment are qualified. Evidence showing that the personnel have passed the tests required by the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB) will be sufficient. The Engineer reserves the right to require that the originally approved personnel be replaced with other qualified personnel if, in their opinion, the original personnel are not qualified or are not properly conducting the system testing.

1.4 SUBMITTALS:

- A. Testing Procedures: Submit six copies of all proposed proof and acceptance testing and operational certification procedures to the Engineer for review at least 30 days prior to conducting any testing or certification.
- B. Reporting Forms: Submit four copies of proposed forms to be used in recording test and certification data and results to the Engineer for review at least 30 days prior to conducting any testing on the project. Data forms from AABC or NEBB will be acceptable.
- C. Test and Certification Data and Results: Submit six copies of complete data and certified test results for each test performed, including, but not limited to:
 - 1. Title Page: Provide the following information on a title page:
 - a. Title
 - b. System(s) tested
 - c. Testing Company Name
 - d. Testing Company Address
 - e. Testing Company Telephone Number
 - f. Testing Company Contact Person
 - g. Project Name
 - h. Project Location
 - i. Project Architect
 - j. Project Engineer
 - k. Project General Contractor
 - l. Other pertinent information
 - 2. Instrument List: Provide the following information on an instrument listing page:
 - a. Instruments
 - b. Manufacturers
 - c. Models
 - d. Serial Numbers
 - e. Ranges
 - f. Calibration Dates
 - 3. Test/Certification Data and Results: Provide pages with applicable test and certification data and results including, but not limited to the following:
 - a. Test/certification performed.
 - b. Test/certification procedure.
 - c. System and area tested.
 - d. Date(s) and time(s) of test.
 - e. Weather conditions.
 - f. Test/certification criteria.
 - g. Test/certification results.
 - h. Additional pertinent information.
- D. Operational Certification: Submit six certified copies of an operational certification which documents that all equipment and systems have been fully tested to verify proper operation in accordance with the design shown in the Construction Documents and manufacturer's recommendations.
- E. Certification of TAB Preparations: The Division 23 Contractor shall certify in writing to the Engineer and TAB consultant, by system and area, when coordination is completed and systems have been fully proof/acceptance tested and are operational and prepared for acceptance testing and balancing by the TAB consultant.
- F. Certification: Certifications stating that submitted data is true and correct shall be provided for all submittals under this Section. Certification shall be executed by an authorized officer if the Contractor is a corporation, by a partner if the Contractor is a partnership, by the Owner if the Contractor is a sole proprietorship or by the authorized representative if the Contractor is a joint venture.
- G. Calibration List: Submit four copies of a listing of testing devices to be used for the project to the Engineer for approval. Listing shall include documentation that devices are properly calibrated.

- H. Test/Certification Log: The Contractor shall maintain a test/certification log at the site to document the results of all successful and unsuccessful testing/certification as it is performed. This log shall be available for review by the Engineer and a copy of the log shall be submitted to the Engineer prior to the Substantial Completion inspection. A space shall be provided on the test/certification log for signoff by the OR/Engineer.
- I. Operating and Maintenance Manuals: Approved copies of Testing Procedures, Test and Certification Data and Results, Operational Certification and Test/Certification Log shall be included in the Operating and Maintenance Manuals specified in Section 23 01 00

1.5 NOTICE:

- A. General: Notify the Engineer in writing two weeks prior to all scheduled testing and certification to allow time for Engineer to schedule witnessing of testing and certification, where elected by the Engineer.

PART 2 - PRODUCTS

2.1 TESTING MATERIALS:

- A. General: Provide all materials, equipment and personnel for all required proof and acceptance testing and preparation for operational testing and balancing, including all required retesting and reparation.
- B. Products: Tested products which fail to provide acceptable test results shall be repaired or replaced with suitable materials and then retested until acceptable test results are obtained.

PART 3 - EXECUTION

3.1 PROOF AND ACCEPTANCE TESTING:

- A. General: Proof and acceptance tests shall be made during the course of construction as specified hereinbelow and in other Sections of this Division and as required by Authorities having jurisdiction. Such tests shall be conducted by this Division as a part of the Work and shall include all provisions, personnel, material and equipment required to perform tests until satisfactory results are obtained. Any defects detected during testing shall be satisfactorily repaired or the equipment involved shall be replaced and the tests re-executed.
- B. Tests: Testing shall include, but not be limited to, all items listed in other Sections of this Division, and the following:
 - 1. Hydrostatic Testing: All pressurized piping [(except diesel fuel, control air, compressed air, laboratory gas, refrigerant and natural gas piping)] shall be hydrostatically leak-tested prior to enclosure or cover-up. Piping shall be leak tested for 24 hours under a hydrostatic pressure of 150% of the system design working pressure, but not less than 225 psi. The Engineer shall be notified prior to all hydrostatic tests and may elect to witness any of the tests. Water shall not be drawn off of the piping and the piping shall not be covered up until it has been approved by the Engineer or OR. Care shall be taken to protect any equipment which may be damaged by hydrostatic testing. Refer to Sections 22 00 00, 22 02 00, 22 04 00 and 23 20 00 for additional test requirements. Following successful testing, domestic water piping shall be sterilized or specified in Sections 23 03 00 and 22 00 00 and chilled [, condenser] [and heating hot] water [and steam and steam condensate piping] shall be flushed and chemical treated as specified in Sections 23 03 00, 23 20 00 and 23 20 10.
 - 2. Pneumatic Testing: All [diesel fuel, control air, compressed air, refrigerant, laboratory gas and natural gas] piping shall be leak tested prior to enclosure or cover-up. [Diesel piping shall be leak tested for 24 hours under a pneumatic pressure of 150 psi.] [Refrigerant piping shall be leak-tested using dry compressed nitrogen for 24 hours at 150% of system high side operating pressure.] [Compressed air and laboratory gas piping shall be leak tested for 24 hours under a pneumatic pressure of 150 psi.] [Natural gas piping shall be leak tested for 24 hours under a pneumatic pressure of five times the service pressure but not less than 100 psi or a higher pressure if required by the natural gas utility.] The Engineer shall be notified prior to pneumatic tests and may elect to witness any of the tests. Air shall not be drawn off of piping until it has

- been approved by the Engineer or OR. Care shall be taken to protect any equipment which may be damaged by pneumatic testing. Refer to Sections 22 00 00, 22 15 14, 22 02 00 and 23 20 00 for additional testing requirements.
3. Leak Testing: All soil, waste, [acid waste,] storm and vent [and acid vent] piping shall be leak tested by temporarily plugging piping stacks and filling the system to be tested with standing water for 3 hours. Water shall not be drawn off of piping and the piping shall not be covered up until it has been approved by the Engineer or OR. Additional testing shall also be provided as required by the local Plumbing Inspection Department. Submit the proposed test procedure and grouping to the Engineer for review. Refer to Section[s] 22 00 00 [and 22 03 00] for addition test requirements.
 4. **[Refrigerant Leak Testing: Leak test and check refrigerant charge on all refrigeration systems at final acceptance and at the end of the warranty period. Repair any leaks found and properly charge affected systems with refrigerant and oil. The Contractor shall certify that all refrigeration systems are properly charged and free from leaks at final acceptance and at the end of warranty (one year from final acceptance).]**
 5. Fire Protection System Hydrostatic Testing: All fire protection piping shall be hydrostatically tested as specified herein above and additional tests shall be performed as Specified in Sections 21 12 00, 21 13 13, 21 13 16 and Section 21 13 18.
 6. Halon Fire Suppression System Testing: Provide testing and certification as specified in Section 21 22 00.
 7. Fire Pump Testing: Provide testing and certification of fire pump operation and capacity as specified in Section 21 30 00.
 8. Domestic Water Pumping System Testing: Provide testing and certification as specified in Section 22 10 00.
 9. Sump Pump and Sewage Ejector Testing: Provide testing and certification as specified in Section 22 11 23.
 10. Fuel Oil System Testing: Provide fuel system testing as specified in Sections 22 02 00.
 11. **[Chiller Capacity Testing: Provide centrifugal chiller field capacity testing as specified in Section 23 64 10.]**
 12. Chiller Oil Sample Testing: Provide oil sample testing and reports as specified in Section 23 64 10.
 13. Cooling Tower Capacity Testing: Provide cooling tower field capacity testing as specified in [Section 23 65 00].
 14. Water Testing: Provide water analysis and testing as specified in Section(s) [22 31 00, 22 50 00,] [and] 23 60 00.
 15. **[Air Handling Unit Acoustical Performance Testing: Provide factory acoustical performance testing for air handling units as specified in Section 23 73 13.]**
 16. Fire, Smoke and Fire/Smoke Damper Testing: Provide fire, smoke and fire/smoke damper testing and certification as specified in Section 23 31 14.
 17. **[Stair Pressurization System Testing: The operation of the pressurization system in each pressurized stair shall be tested as follows:]**
 - a. **[Verify fan stop/start control from the fire alarm system, including firefighters' override.]**
 - b. **[Verify duct smoke detector shutdown of fan.]**
 - c. **[Verify fire alarm system monitoring of fan status.]**
 - d. **[Verify proper operation of the fan inlet damper [and that the stair relief damper is closed with the fan off].]**
 - e. **[Certify the results of all tests and verification hereinabove, for each pressurized stair.]**

18. **Smoke Management System Testing:** The operation of the smoke management system [on each floor] [and in the atrium] [in each building smoke compartment] shall be tested as follows:
 - a. [Verify smoke management activation/deactivation from the fire alarm system, including firefighters' override.]
 - b. [Verify fan start/stop control from the fire alarm system, including proper speed selection and firefighter's override and speed selection.]
 - c. [Verify fire alarm system monitoring of fan status.]
 - d. [For each floor [and the atrium], verify that smoke removal dampers [and makeup dampers], as applicable, open properly upon signal from the fire alarm system, including firefighter's override.]
 - e. [Certify the results of all tests and verification hereinabove, for each smoke compartment [and the atrium].]
19. **Fire Alarm System Interface:** Provide testing, in conjunction with the Fire Alarm System functional testing specified in Division 26, to verify that all fire alarm related HVAC control functions and shutdowns operate as specified in [Section 23 06 00] [Division 23], Division 26 and as shown on the Drawings.
20. **Duct Leakage Testing:** Provide duct integrity and leakage testing as specified elsewhere in Division 23.
21. **Operational Testing:** The Contractor shall test all systems and components installed in the building to verify proper operation is provided as described in the specifications and manufacturer's recommendations.
22. **Vibration Isolation Certification:** Provide certification of the installation of vibration isolation as specified in Section 23 05 48.
23. **BCAS Testing and Certification:** A complete BCAS checkout and test shall be performed by the Division [23] Contractor to demonstrate and certify that the BCAS is 100% operational and adjusted upon completion of the installation, and that it complies with all applicable codes and specification requirements.] [The Division 23 Contractor shall participate in the BCAS testing and certification process to assure that HVAC, plumbing and fire protection systems, equipment and related BCAS interfaces perform as specified.]
 - a. [The system checkout and test shall be performed within 30 days of the completion of system installation, adjustment and commissioning. Testing shall be performed in two parts and two-way radios for use by test observers shall be provided. The first part of the test shall be a full test of all system components, functions, and alarms. All affected subcontractors shall participate in this test. Test results shall be certified and submitted to the Engineer. This test shall be the basis for the System Acceptance document specified in Section [23 06 00] [_____]. The second part of the test shall be a demonstration of basic system functions and alarms for the Engineer and Owner's Representative.]
 - b. [This contractor shall coordinate the test schedule with the General Contractor, Electrical Contractor, Mechanical Contractor, Fire Protection Contractor and other Contractors required to be present for a complete and functional test.]
 - c. [The system checkout and test shall be a comprehensive 100% inspection and functional test of all equipment and software and shall include, but not be limited to, the following:]
 - 1) [Verification of manual and program control of all start/stop and alarm points, including status indication and alarms.]
 - 2) [Verification of all controlled points including setpoint and actual point readouts, remote setpoint change and point alarm.]

- 3) **[Verification of all alarm points.]**
- 4) **[Verification that all system annunciation text and messages are correct and appropriate.]**
- 5) **[Functional test of the normal and emergency power building start-up and shutdown routines.]**
- 6) **[Testing to verify that all systems on emergency power operate as specified in the sequence of operation.]**
- 7) **[Testing to verify that all control functions specified in the sequence of operation are provided and fully functional as specified and required.]**
- 8) **[Testing to verify that all specified software is provided and fully implemented.]**

d. **[Submit four copies of a letter certifying that the BCAS is properly and fully installed and fully adjusted and calibrated to operate as specified to the Engineer for review prior to final acceptance.]**

24. Emergency Power Operation Testing: Testing of BCAS, HVAC, plumbing and fire protection system operation under emergency power shall be coordinated with the Division 16 Contractor such that the testing is conducted along with the Division 16 emergency power system testing and certification.
 25. Sewer Rodding: All sanitary and storm sewer piping shall be free of obstructions both inside the building and to the points of connection to public utility systems. If blockage develops in any sanitary or storm piping within the warranty period and the blockage is due to construction related debris or defects, this Contractor shall be responsible for the cost of rodding out the piping to remove the blockage or obstruction. The rodding shall be done at no additional cost to the Owner or Engineer. Notify the Engineer prior to proceeding with rodding of any piping.
- C. Authorities Having Jurisdiction: The Division 23 Contractor shall also perform any additional proof and acceptance testing required by all applicable Authorities having jurisdiction over the project.

3.2 SYSTEM ADJUSTMENTS:

- A. General: Systems installed under this Division, except HVAC air **[and water]** balancing shall be adjusted by the Division 23 Contractor to provide proper operation.
- B. Adjustments: Systems to be adjusted shall include, but not be limited to:
 1. Domestic Hot Water System Balancing and Adjustments: Water flow through the domestic **[and kitchen]** water heaters shall be balanced to provide an equal volume through each water heater. Water heater thermostats **[and circulating pump aquastats]** shall be adjusted to provide a true **[115°F] [120°F] [and] [140°F]** hot water supply in the building domestic **[and kitchen]** hot water loop[s]. Hot water system balancing valves shall be adjusted to provide indicated flows, prior to Final Acceptance.
 2. Steam System Adjustments: The steam boilers and steam pressure reducing valves shall be adjusted to provide the scheduled steam pressure in the building supply systems, prior to Final Acceptance.
 3. Miscellaneous Controls and Alarms: Adjust and test all miscellaneous pressure, temperature, flow, level, refrigerant and similar controls and related alarm systems and monitoring to provide proper operation.
 4. Control Balancing: All control systems and equipment installed on the project shall be programmed, calibrated and/or adjusted to provide proper operation or function in accordance with the drawings, specifications and manufacturer's recommendations. This programming, calibration and adjusting shall be completed as part of the preparations for air and water system balancing specified hereinbelow.

3.3 OPERATIONAL CERTIFICATION:

- A. General: Submit HVAC, plumbing and fire protection systems to operational tests to demonstrate satisfactory system operation.
- B. HVAC Systems: Operationally test project HVAC systems to demonstrate satisfactory operation. Operation tests shall include, but not be limited to:
1. Boiler operation and discharge pressure.
 2. Steam pressure at inlet and discharge from each steam PRV.
 3. Boiler feed pump operation and alarms.
 4. Condensate return unit operation and alarms.
 5. Chiller operation, interlocks, controls and alarms.
 6. Cooling tower operation, fill valves and vibration shutdown.
 7. Control air compressor and air dryer operation.
 8. Results of other HVAC system tests.
 9. Test results for all piping system tests.
 10. Test results for all ductwork leakage tests.
 11. Test results for HVAC system water treatment.
 12. Time, date and duration of each test.
- C. Plumbing Systems: Operationally test project plumbing systems to demonstrate satisfactory operation. Operational testing shall include, but not be limited to:
1. Water pressure at inlet and discharge of each PRV.
 2. Water pressure at most remote and highest fixtures.
 3. Operation of each fixture and fixture trim.
 4. Operation of each valve, hydrant and faucet.
 5. Operation of each backflow preventer and vacuum breaker.
 6. Operation of each floor and hub drain by flooding with water.
 7. Operation of each trap primer.
 8. Operation of all pumps and related controls and alarms.
 9. Suction and discharge pressure at each pump.
 10. Service water pressure.
 11. **[Operation of house tank fill valves and alarms.]**
 12. **[Operation of water softener and inlet and outlet water sample hardness analysis.]**
 13. Operation of domestic water heaters and supply/return water temperature at each heater.
 14. **[Operation of sump pumps and sewage ejectors including lead/lag and level controls and alarms.]**
 15. **[Operation of [medical] [laboratory] pumping systems and related alarms. Pressures/Vacuum at system inlets/outlets.]**
 16. **[Medical gas piping system alarms.]**
 17. **[Fuel oil system controls, monitoring and alarms. Proper operation of fuel oil return system.]**
 18. Results of other required plumbing system tests.
 19. Test results for all piping system leakage tests.
 20. Test results for disinfection of domestic water system.
 21. Time, date and duration of each test.
- D. Fire Protection Systems: Operationally test project fire protection systems to demonstrate satisfactory operation. Operational testing shall include, but not be limited to:
1. Fire Service water pressure.
 2. Operation of fire and jockey pumps.
 3. Operation of fire protection/suppression systems.
 4. Suction and discharge pressure at each pump.
 5. Results of fire pump flow test.
 6. Results of other required fire protection system tests.
 7. Test results for all piping system leakage tests.
 8. Test results for disinfection of fire water systems.
 9. Time, date and duration of each test.

3.4 PREPARATION FOR OPERATIONAL TESTING AND BALANCING:

- A. General: All air [, **water**] and control systems installed on the project shall be balanced and/or adjusted to provide proper operation or function in accordance with the drawings, specifications and manufacturer's recommendations. Refer to Section 230593 for HVAC air [, **water**] and control system operational testing and balancing. System startup and preparation for operational testing and balancing shall be provided under this Section.
- B. Provisions for Operational Testing and Balancing: The Division 23 Contractor shall install all provisions for operational testing and balancing as shown on the drawings, specified and required by the TAB Consultant. These provisions shall include, but not be limited to all control, regulating and readout devices necessary to operationally test and balance all air [, **water**] and control systems including, but not limited to: thermometers; pressure gauges; [**air monitoring stations;**] [**flow meters;**] [**flow venturis;**] balancing valves; air volume, splitter and extractor dampers; pressure taps; temperature taps and wells; pitot tube ports; and other necessary provisions.
1. The Division 23 Contractor shall notify the Engineer in writing and receive clarification in writing prior to submitting a bid, if in the Contractor's opinion, any required provisions have been omitted. Submission of a bid constitutes an agreement that all provisions required for operational testing and balancing shall be provided at no cost to the Owner or Architect/Engineer, regardless of whether such provisions are specifically shown on the drawings or in the specifications.
- C. Coordination and Scheduling: The Division 23 Contractor shall coordinate and schedule preparations for operational testing and balancing with the TAB Consultant. This coordination and scheduling shall include, but not be limited to:
1. Coordinate exact locations of operational testing and balancing provisions with the TAB Consultant.
 2. Sequence completion of preparation for operational testing and balancing to allow adequate time for the TAB Consultant to complete operational testing and balancing prior to project substantial completion.
- D. TAB Consultant Input: the Division 23 Contractor shall provide input to the TAB Consultant including, but not limited to:
1. Fan and pump curves and performance data.
 2. Performance data on [**boilers,**] chillers, heat exchangers, cooling towers and coils.
 3. All approved HVAC Shop Drawings.
 4. Belt drive data on all belt driven equipment.
 5. As-built drawings accurately showing locations of all measuring and balancing devices, air vents and drain valves.
 6. Control diagrams and sequence of operation.
 7. Copies of all HVAC RFI's and Change Orders.
 8. Additional input required by the TAB Consultant.
- E. TAB Consultant Noted Deficiencies: The Division 23 Contractor shall correct any deficiencies noted to the TAB Consultant during the operational testing and balancing process. Corrections shall be made in a timely manner so as not to impede the work of the TAB Consultant. These corrections shall include, but not be limited to:
1. Relocating test points and sensors/controllers which are installed or positioned in a manner which prevents correct measurement or sensing of temperatures, pressures, humidity, etc. and to provide sufficient access to these devices.
 2. Corrections to control functions which do not operate in accordance with the sequence of operation.
 3. Recalibration of control devices.
 4. Relocation of air and water taps which are installed or positioned in a manner which does not allow design flows to be obtained in the tap.
 5. Relocation of balancing and control devices to provide sufficient access to these devices.
 6. Addition of required balancing dampers and valves.

- F. **Preparation for Air Balancing:** All **[Base Building and new]** air systems shall be completely installed, operational and prepared prior to commencing with air balancing. The minimum steps required for preparation for air balancing shall include, but not be limited to:
1. **Inspection:** Inspect and certify in writing that the complete air system including, but not limited to: air handling equipment, fans, terminal units, coils, ductwork, air devices, dampers, controls, balancing devices, access doors, test ports, return air paths, partitions to deck and doors in partitions to deck are installed and operational, as applicable.
 2. **Operation:** Certify that the complete air system is operable and operates in a safe and normal manner.
 3. **Dampers:** Inspect and certify in writing, that all required volume, splitter, extractor, fire, smoke and fire/smoke dampers are installed, that all balancing dampers are in the open and locked position, that all fire dampers are open, that all fire/smoke, smoke and control dampers open and close properly in response to control sequences and that all access doors are closed and sealed.
 4. **Fans:** Adjust and verify in writing that all fans are operating properly, are rotating at design fan RPM in the proper direction, are free from vibration, have proper belt tension and that properly sized overload elements are installed in motor starters, where motors are not self-protected. Record motor nameplate data and measured voltage and amperage on each phase at initial motor startup.
 5. **[Variable Speed Drives (VSD's): Verify in writing that all VSD's have been factory pre-tested prior to shipment and field tested for proper operation and controls interface.]**
 6. **Controls:** Verify in writing that all required air system controls, interlocks and safety devices are fully operational and that all controlling devices are calibrated and set for designed conditions.
 7. **Testing:** Verify in writing that all specified duct leakage and fire, smoke and fire/smoke damper testing has been successfully completed and that duct systems are clean and free of any dirt or debris.
 8. **Cleaning:** Install clean air filters in all equipment and, where equipment has been operated, clean coils and vacuum equipment interior in preparation for balancing. Comb out any coiled fins damaged by construction or cleaning. The Engineer and OR shall be the final decision makers on whether coils and equipment must be cleaned prior to balancing.
 9. **Notification:** Notify the Engineer and TAB Consultant in writing when all items required in paragraphs 3.04B, 3.04C, 3.04D 3.04E and 3.04F/1-8 have been completed for a specific air system and certify that the system is operational and prepared for operational testing and balancing.
- G. **Preparation for Chilled[, Condenser] [and Heating Hot] Water Balancing:** All **[Base Building and new]** chilled[, condenser] [and heating hot] water systems shall be completely installed, operational and prepared prior to commencing with water balancing. The minimum steps required for preparation for water balancing shall include, but are not limited to:
1. **Inspection:** Inspect and certify in writing that the complete water system including, but not limited to pumps, heat exchangers, coils, piping, valves, meters, venturis, gauges, thermometers, test ports and controls are installed and operational, as applicable.
 2. **Operation:** Certify that the complete HVAC water system is operable and operates in a safe and normal manner.
 3. **System Filling:** Verify and certify in writing that water systems are full of water and free of air, that water treatment has been installed, that properly operating air vents are installed at all system high points, that drain valves are installed at all system low points and that expansion/compression tanks are properly charged and are not water logged.
 4. **Valves:** Inspect and certify in writing that all stop, isolation, balancing and control valves are open and that all bypass valves are closed. Mixing valves shall be open to system components.
 5. **Pumps:** Check and certify in writing that pumps are properly aligned, that pump bases have been grouted, that pumps are rotating in the correct direction, that pumps are free from vibration

and that properly sized overload elements are installed in motor starters. Record motor nameplate data measured and voltage and amperage on each phase at initial motor startup.

6. **[Variable Speed Drives (VSD's): Verify in writing that all VSD's have been factory pre-tested prior to shipment and field tested for proper operation and controls interface.]**
7. Controls: Verify in writing that all required water system controls, interlocks and safety devices are fully operational and that all controlling devices are calibrated and set for design conditions.
8. Testing: Verify in writing that all specified piping system leakage testing has been successfully completed.
9. Cleaning: Verify in writing that all specified system flushing and cleaning has been completed and that all system strainers have been removed, cleaned and reinstalled.
10. Notification: Notify the Engineer and TAB Consultant in writing when all items required in paragraphs 3.04B, 3.04C, 3.04D, 3.04E and 3.04G/1-9 have been completed for a specific HVAC water system and certify that the system is operational and prepared for operational testing and balancing.

3.5 PROJECT COMPLETION:

- A. General: Prior to Project Substantial Completion, the Contractor shall provide project completion services necessary to complete the project including, but not limited to:
 1. Sheave Replacement: Replace adjustable sheaves with permanent fixed position sheaves. Fixed sheaves shall match the RPM set on the variable pitch sheaves by the TAB Consultant.
 2. Completion Reports: After all testing, balancing and adjusting, the Contractor shall furnish all labor, materials and devices necessary to prepare a completion report with the following information.
 - a. Motor data on all motors installed on the project. Motors shall be listed by the device on which they are installed and information provided shall include: horsepower, speed, type, location, rated full load amperage, rated voltage, actual measured amperage for each leg and actual measured voltage for each leg.
 - b. Belt and drive data for all belt driven equipment installed on the project. Data shall be listed by the device on which the belts and drive are installed and information provided shall include: number of belts, size of belts, size and type of drive installed, motor rpm and driven device rpm.
 - c. Fan speed data shall be measured and recorded in rpm, for each belt drive and variable speed fan.

[INCLUDE THE FOLLOWING ON SHELL SPACE OFFICE BUILDINGS ONLY]

3. **[Re-adjustment: During the period between 6 months to one year after Final Acceptance, adjust each fan and blower to a new rotative speed as selected by the Owner. Provide two sets of fixed drives and necessary labor for installation to accomplish all required fan speed adjustments during this period.]**

END OF SECTION 23 05 93

SECTION 23 07 00 - SYSTEM INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.
- B. Refer to Section 23 31 13, "Ductwork", for duct lining requirements and Section 23 37 13, "Air Distribution Devices", for additional insulation requirements.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide piping, ductwork, and equipment system insulation as specified.

1.3 QUALITY ASSURANCE:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
 - 1. Armstrong World Industries.
 - 2. Certain-teed Corporation.
 - 3. Rubatex LLC
 - 4. Resolco Insul-phen
 - 5. Schuller.
 - 6. Owens/Corning Fiberglass.
 - 7. Pittsburgh Corning.

1.4 SUBMITTALS:

- A. Shop Drawings submittals shall include, but not be limited to, the following:
 - 1. Cut sheets on all insulation products to be used.
 - 2. Cut sheets on all mastics and other products to be used with insulation products.
 - 3. Cut sheets on PVC and aluminum jacketing materials.
 - 4. Manufacturer's printed installation instructions for all of the above products.
 - 5. Additional information as required in Section 23 01 00.

1.5 DELIVERY, STORAGE AND HANDLING:

- A. Store insulation products in their factory-furnished coverings, and in a clean, dry indoor space which provides protection against the weather.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. Quality: The type of insulation and its installation in accordance with this Section of the Specifications for each service and the application technique shall be as recommended by the manufacturer.
- B. Fire Rating: All insulation shall have a composite (insulation, jacket or facing and adhesive used to adhere facing or jacket to insulation) fire and smoke hazard, as tested by ASTM E84, NFPA 255, and UL 723, not to exceed:
 - 1. Flame Spread 25.
 - 2. Smoke Developed 50.
- C. Accessories: Accessories such as adhesives, mastics, tapes, and cements shall have the same component ratings as listed.
- D. Labels: Label products and their shipping cartons indicating that flame spread and smoke developed ratings do not exceed the above requirements.

2.2 INSULATION THICKNESS:

A. Minimum: Insulation thickness shall not be less than the following:

Equipment Surface (Non-factory Insulated Equipment [**Cold**] [**or**] [**Hot**] Surfaces)

Chilled water pumps	1"
Chillers	1"
Water-to-water heat exchangers	1-1/2"
Steam-to-water heat exchangers	1-1/2"
Cooling tower basins & sumps	1"
Steam and steam condensate vessels	2"
Diesel engine silencers and exhaust piping	3"
Heating water [and auxiliary condenser water] pumps	1-1/2"
Coils	1-1/2"
Compression/expansion tanks	1"
[House, surge and water storage tanks	1"]
Boiler stack and breeching	2"
Outside air fans	1"
Condensate drain pans	1"

Piping Surface

Chilled water 1" and smaller[, domestic refrigerated water [, condenser water] [and] [heating hot water] [runouts]	[1"] [____"]
Chilled water piping, 1-1/4" to 2" and heating hot water [mains]	[1-1/2"] [____"]
Chilled water piping 2-1/2" and larger	[2"] [____"]
Steam piping 6" and larger	3-1/2"
Steam piping 4" and smaller [and all steam relief vent piping]	2-1/2"
Steam condensate piping, 2" and smaller	1-1/2"
Steam condensate piping, 2-1/2" and larger	2"
Steam condensate vent piping	1"
Refrigerant piping	1"
Condensate drain piping (except above drain pans and less than one foot (1') at floor drains)	1/2"
Roof and overflows drains (underside), horizontal downspouts, underside of drains (including traps) and horizontal drain lines from chilled water drinking fountains and drains receiving cooling coil condensate.	1/2"
Plastic acid waste and vent lines	1"
Domestic hot water lines 2" and smaller	1"
Domestic hot water lines 2-1/2" and larger	1-1/2"

Domestic cold water [mains, risers and horizontal runouts] [all lines below third floor]	1/2"
[Handicapped] [All exposed] lavatory traps, tailpieces hot and cold water supplies	1"
Deionized (treated) water lines	1/2"
Cooling tower make-up water lines	1/2"
Garage fire and domestic water lines exposed to outdoor temperatures [, 2-1/2" and smaller]	1-1/2" [____"]
All otherwise uninsulated pipe exposed to outdoor temperatures	[1-1/2"] [____"]

Ductwork Surface

Conditioned air [and return air***] ductwork, external wrap (where not lined)	1-1/2"
Air devices***	1-1/2"
Kitchen exhaust ductwork	2"
Wet exhaust ductwork	1-1/2"
Ductwork, acoustical lining (see Section 233113).	
Return air ductwork, exterior wrap ***	1-1/2"

- * Where exposed to outdoor ambient temperature, increase insulation thickness by 1/2".
- ** Unless noted otherwise.
- *** Where located in non-return air plenums (e.g. ducted return areas).

2.3 EQUIPMENT:

- A. Hot (110° F to 200° F) and Cold (Below 60° F) Surfaces: Provide Armstrong Type II "Armaflex", "Robatex", or an approved equal flexible closed cell elastomeric sheet insulation. Insulation shall have a K factor of not more than 0.28 Btu/inch-per degree F-per hour at 75° F mean temperature and a water vapor permeability of 0.15 perm-inch or less. Insulation shall have a flame spread rating of 25 and a smoke-developed rating of 50 for thicknesses up to 3/4" and 200 for one inch (1") thickness. Provide manufacturers recommended adhesive (Armstrong 520 or an approved equal.)
- B. High Temperature (200°F and Above) Surfaces: Provide Schuller "Thermo-12" or an approved equal hydrous calcium silicate in scored block or beveled block form, as best suited for the intended use. Where exposed to weather, provide Schuller "Metal-On" or approved equal metal weatherproof jacket.

2.4 PIPING:

- A. Chilled and Hot Water Pipe Insulation: Provide Resolco International by (Insul-Phen) or an approved equal pre-formed Phenolic closed cell insulation; ASTM E96, maximum water vapor transmission rating of 0.02 Perm-In; ASTM C1126 rigid foam, 3.75 lbs. nominal density, CFC free; ASTM C518, 'k' value of 0.16 at 75 degrees F., and 5.0 lbs. nominal density, CFC free; ASTM C518, 'k' value of 0.21 at 75 degrees F. (Note material thickness limit is 3 inches as tested in accordance with ASTM E84).
- B. Calcium Silicate Pipe Insulation (Steam Supply Piping): Provide Schuller Thermo-12, Owens/Corning Kaylo AF or an approved equal pre-formed calcium silicate insulation. Calcium silicate pipe insulation sections shall be pre-formed specifically for the pipe sizes on which it is used. Calcium silicate insulation shall be held in place with 20 gauge galvanized wire on 9" centers. Sections shall be formed to provide tightly butted joints. Material shall have a K factor of 0.55 at 500° F mean.

- C. Fitting Insulation: Provide pre-molded rigid insulation for valves, fittings, flanges, strainers, and unions. Insulation shall be as specified for pipe insulation, except without the all-service jacket, where applicable.
- D. Factory Applied Jackets: White kraft bonded to reinforced foil vapor barrier with self-sealing adhesive joints.
- E. Existing and/or repaired Phenolic Insulation: Provide Venture 1577 W/U, 0 perm and mold resistant jacket material, 5 ply laminate with 6 mil film on with adhesive on one side. .
- F. Fiberglass Cloth Reinforced Mesh: Provide # 10 glass cloth with minimum weight of 3.9 ounces per square yard. Color shall be white unless noted otherwise.
- G. PVC Jacketing: Provide pre-rolled protective jacketing where required or specified for protection of the insulation all service jacket. PVC jacketing shall be 30 mil thickness. All joints shall be made by lapping the jacket and sealing with an approved PVC welding adhesive.
- H. Metal Jacketing: Provide 0.016" thick aluminum jacketing where required or specified. 3/4" x 0.015" stainless steel bands and straps shall be provided for banding insulation jacketing.
- I. Elastomeric Insulation: Provide Armstrong Type II "Armaflex" or approved equal closed cell elastomeric insulation. Insulation shall have a K factor of not more than 0.28 Btu/inch per degree F-per hour at 75° F mean temperature and a water vapor permeability of 0.15 perm-inch or less. Insulation shall have a flame spread rating of 25 and a smoke developed rating of 50. Provide manufacturers recommended adhesive (Armstrong 520 or Manville No. 57).
- J. Lavatory Piping: Provide Truebro Model #102 or Plumberex PR0-2000 series or equal fully molded, flexible vinyl insulation system for insulating lavatory traps and hot and cold water supplies.
- K. Miscellaneous: Provide all miscellaneous accessories, components and materials required for installation of a complete insulation system.

2.5 DUCTWORK:

- A. External Ductwork Insulation: Provide Schuller "Microlite" R-Series or an approved equal **[1-1/2"] [2"] [2-1/2"] [3"]** thick flexible fiberglass duct wrap with fiberglass reinforced kraft-scrim-foil vapor barrier jacket. Ductwrap shall have a density of 0.75 pounds per cubic foot, K factor of 0.31 at 75° F and a permeability of 0.04 perm. Insulation shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less.
- B. Acoustical Duct Lining: Lining provided with ductwork, refer to Section 23 31 13.
- C. Kitchen Exhaust Ductwork: Provide **[calcium silicate insulation as specified hereinabove for "High Temperature (200° F and Above) Surfaces".] [High temperature fiberglass blanket (1000° F) insulation, 2# density with a K-factor of 0.23 at 75° F. Insulation shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less.]**

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install insulation products in accordance with the manufacturer's written instructions, the Midwest Insulation Contractors Association (MICA) Commercial and Industrial Insulation Standards, and recognized industry practices to ensure that the insulation serves the intended purpose. Surfaces to be insulated shall be thoroughly cleaned with all testing successfully completed prior to insulation.

3.2 EQUIPMENT APPLICATION:

- A. Chilled **[and Heating Hot]** Water Pumps: Apply sheet insulation to the surface to be insulated with adhesive over the entire surface. The entire insulation installation shall be in accordance with application recommendation described in the latest published manufacturers pamphlets. All lap and butt joints shall be sealed vapor tight. The insulation shall be finished with two coats of manufacturer's finish coating, vinyl-lacquer coating, or approved equal, color to be [manufacturer's standard] [as selected by the Owner]. Application shall be such that removal of the pump casing or a pump casing section will not destroy the installation, and as detailed on the Drawings.

- B. Water Chillers and Heat Exchangers: Apply sheet insulation to hot heat exchangers and non-factory insulated cold surfaces on water chillers with adhesive over the entire surface being insulated. The entire insulation installation shall be in accordance with application recommendations described in the latest published manufacturers pamphlets. All lap and butt joints shall be sealed, vaportight on cold surfaces, using the manufacturers recommended adhesive. The insulation shall be finished using two coats of the manufacturer's finish coating, vinyl-lacquer coating, or approved equal, color to be [manufacturer's standard] [or selected by the Owner]. Insulation installation shall have removable sections to allow maintenance access.
- C. Compression/Expansion Tanks and Water Storage Tanks: Apply sheet insulation to the entire surface with recommended adhesive. Apply adhesive over the entire clean dry bare metal surface and all butt and lap joints shall be sealed vaportight. The entire insulation installation shall be in accordance with application recommendations described in the latest manufacturers pamphlets. The insulation shall be finished with two coats of manufacturer's finish coating, vinyl-lacquer coating, or approved equal, color to be [manufacturer's standard] [as selected by the Owner].
- D. Diesel Engine Exhaust Pipes and Silencer, Boiler Stack, and Breeching and High Temperature Heat Exchangers and Converters: After all pressure tests have been completed, apply calcium silicate insulation with joints staggered to clean, dry metal surfaces, which have not been factory-insulated and hold in place with one inch (1") galvanized hexagonal wire mesh with edges laced together. Where necessary to achieve snug fit of insulation on large surfaces, install weld clips 18" on center to surfaces before installation of insulation and tie to wire mesh with 20 gauge galvanized wire. [Cover insulation with two 1/4" thick coats of insulating cement troweled to a smooth finish and reinforced with one inch (1") hex wire mesh. When cement has cured, apply a layer of 20 x 20 mesh glass fabric adhered with Insul-Coustic IC 102 and then give a flooding brush coating of IC 102.] [Cover insulation with 2" fiberglass pipe insulation as specified for heating hot water piping.]
- E. Exterior Installations: Where systems are exposed to ambient temperatures or wet conditions and elsewhere as specified, provide an aluminum jacketing system specifically designed for exterior installation. All longitudinal seams shall be located at the 3 o'clock and 9 o'clock position with a minimum 3" overlap oriented to shed water from entry. Butt joints shall be overlapped a minimum of 3" in a manner to prevent the entry of water. Seal metal jacketing with straps on maximum 12" centers. Locate strap joints so as to prevent personnel contact. A factory-applied metal jacket on calcium silicate systems meeting all aspects of this specification may be used where exposed to ambient temperatures or wet conditions if installed per the manufacturers recommendations.
- F. Cooling Tower Basins and Sumps: Insulate as specified for water chillers. Finish with two coats of exterior grade vinyl coating applied per the manufacturers recommendations.
- G. Outside Air Fans: Insulate all outside air fans located in enclosed spaces and not exposed to outside temperatures as specified for water chillers.
- H. Condensate Drain Pans: Insulate all non-factory-insulated drain pans as specified for water chillers.
- I. Steam and Steam Condensate Vessels: Insulate all non-factory-insulated surfaces as specified for boiler breeching where surface temperatures exceed 200°F. [Atmospheric pressure receiver condensate pump units do not require full insulation.]
- J. Heating and Cooling Coils: Insulate all coil perimeter surfaces that are not factory-insulated with fiberglass insulation as specified for external duct insulation.

3.3 PIPING APPLICATION:

- A. General: Apply insulation to clean, dry pipes after all pressure tests have been completed. Firmly butt all joints of insulation and seal all joints per manufacturers recommendations. Install insulation in strict accordance with these specifications and the manufacturer's printed instructions.
- B. Flanges, Strainers and Unions: Insulate flanges, strainers, and unions with pre-molded or shop-fabricated rigid insulation of same material and thickness as specified for adjacent piping. Cover fiberglass [and polyurethane] insulation with pre-molded PVC covers, held in place with Zeston "Z-tape" or an approved equal. Covers and finish for foam glass and calcium silicate insulation shall be as specified for the adjacent pipe insulation. Ensure that insulation and covers for flanges, unions, and access plates shall be removable without damage to insulation or jackets.

- C. Valves and Fittings: Insulate and cover valves, tees, elbows, test parts, and other fittings the same as flanges and unions.
- D. Lavatories: Where specified, insulate exposed tailpieces, traps, and hot and cold water supplies with fully molded, flexible vinyl insulation installed per the manufacturers recommendations.
- E. Chilled Water Piping: Install pre-formed Phenolic insulation to provide a continuous vapor barrier/insulation system. Insulation shall be installed on piping with butt joints staggered and all joints buttered with Pittseal 444 or approved equal sealant and tightly butted together. Secure insulation with stainless steel bands with a minimum of two bands per insulation section. Cracked or damaged insulation shall be replaced. Valves, fittings, and accessories shall be insulated to the same thickness of insulation specified for piping and shall use step-type layering or pre-formed insulation. Butt joints shall be rested to avoid gaps or voids. Fill contour space between insulation and valves and fittings with light density fiberglass. At valves, fittings, and accessories and at intervals not exceeding 50' on straight runs of pipe, form an isolating seal between the insulation and the bare pipe by liberal application of butt joint sealant. Coat the installed Phenolic with a tack coat of Pittcoat 300 or approved equal vapor barrier mastic per manufacturers recommendations, embed a layer of PC Fabric 79 or approved equal reinforcing fabric in wet mastic, smooth and without wrinkles and then apply a second coat of mastic (before the tack coat cures) such that there is no fabric visible through the mastic. Size and pre-treat coating as recommended by manufacturer where piping is to be painted in mechanical rooms [and tunnels].]
- F. **[Chilled Water,] [Domestic Refrigerated Water, [Pumped AHU Condensate,] Condensate Drains, Drains Receiving Condensate and from Refrigerated Water Drinking Fountains, Roof Drains, Overflow Roof Drains, and Horizontal Roof, Areaway, and Overflow Roof Drain Leader Piping]**: Install pre formed fiberglass insulation to provide a continuous external vapor barrier on all pipe insulation. Seal insulation lap joints using [Insul-Coustic No. 215 or equal vapor barrier adhesive on insulation butts and] the manufacturer's standard pressure sensitive self-sealing lap joint system. Seal butt joints using [Insul-Coustic No. 215 or equal vapor barrier adhesive on insulation butts and] the manufacturer's standard pressure-sensitive closure strip system. Butt strips shall be a minimum of 3" wide. Where insulation is interrupted at fittings, unions, flanges, or valves and at intervals not exceeding [24'] [50'] on straight runs of pipe, form an isolating seal between the insulation vapor barrier and the bare pipe by liberal application of Insul-Coustic No. 215 or equal vapor barrier adhesive. Extend the adhesive 2" along the insulation jacket, across the face of the insulation and 4" along the pipe. [At the Contractors option, roof drain bodies and horizontal roof drain piping may be insulated using exterior ductwrap installation with a continuous vapor barrier.] [Install a protective outer covering using a metal jacket system over [all] [exposed interior and exterior] pipe [and fitting] insulation. [Metal jacketing is not required over indoor PVC fitting covers.] Refer to Paragraph 3.03/P for additional requirements.]
- G. **Domestic Hot and Cold Water Piping, Heating Hot Water Piping, Kitchen Grease and Kitchen General Waste Lines and other Piping which is Insulated where Exposed to Outdoor Temperatures**: Install phenolic insulation to provide a continuous external vapor barrier on all pipe insulation. Seal insulation lap joints using the manufacturer's standard pressure-sensitive self-sealing lap joint system. Seal butt joints using the manufacturer's standard pressure-sensitive closure strip system. Butt strips shall be a minimum of 3" wide. At the Contractor's option, staples (as specified for steam and condensate piping) may be used in lieu of self-sealing closures for hot piping. [Install a protective outer covering using a metal jacket system over [all] [exposed interior and exterior] pipe [and fitting] insulation. [Metal jacket is not required over indoor PVC fitting covers.] Refer to Paragraph 3.03/P for additional requirements.]
- H. **Steam and Steam Condensate Piping**: [Install calcium silicate insulation on the entire piping system. Seal insulation lap joints on pre-formed fiberglass using insulation staples on 2" centers. Seal edge of lap joints with Insul-Coustic No. 215 or equal adhesive or a pressure sensitive tape strip to provide a seal to prevent water entry. Seal butt joints using the manufacturer's standard pressure-sensitive closure strip system. Butt strips shall be a minimum of 3" wide.] [Install pre-formed calcium silicate insulation on piping and fittings with butt joints staggered and with insulation firmly wired in place with a minimum of six

loops of 16 gauge copper clad iron wire per 3' section. Loop ends shall be twisted together tightly and bent over and hammered into the insulation so as to leave no projection. All cracks and voids in the insulation shall be filled with Manville 301 or approved equal cement such that the resulting surface is smooth and continuous. A layer of 40 pound rosin-sizing paper shall be wrapped around the insulation and an 8 ounce canvas jacket shall be pasted in place. The canvas jacket shall be finish-coated and sized for color-coded finish-painting.] [Install a protective outer covering using a metal jacket system over [all] [exposed interior and exterior] pipe [and fitting] insulation. [Metal jacket is not required over indoor PVC fitting covers.] Refer to Paragraph 3.03/P for additional requirements.]

- I. Refrigerant Piping: Install phenolic insulation (if specs allow) to refrigerant and hot gas lines. Seal all butt joints using the manufacturers recommended adhesive.
- J. Hangers and Supports: Blocking (for piping with a vapor barrier) or saddles (for piping without a vapor barrier) shall be provided at all hanger and support locations. Install insulation inside all pipe saddles. Extend vapor barrier across all pipe blocking. Refer to Section 230300, "Basic Materials and Methods", for additional requirements.
- K. Pipe Anchors: Insulate pipe anchors as specified for piping. Provide an isolating seal at anchors on piping with a vapor barrier as specified under Paragraph 3.03/D.
- L. Pipe Accessories: Valve operators, pressure/temperatures plugs, meters and gauge fittings and all other items which extend through required insulation shall be suitably insulated with removable caps to allow use without disturbing the insulation.
- M. Heat Tracing: Where pipe is heat-traced, the insulation size shall be increased accordingly.
- N. Central Plant [and] [,] [Mechanical Room] [and Tunnel] Protective Covering: Protect the insulation jacket on all fiberglass [and polyurethane] insulation and accessories in the Central Plant [and] [,] [mechanical room] [and tunnels] [and within 6'-0" of finished floor in mechanical and air handling unit rooms] with a field-installed covering using [vapor barrier mastic and reinforcing mesh installed per the manufacturers recommendations] [except where metal jacket is specified]. [The insulation surface, covering or jacket on all piping in the Pump Room, Mechanical Rooms, and tunnels shall be sized, coated and prepared as required for finish color-coded painting.]
- O. Below Grade Protective Jacket: Protect outer covering of insulation on below grade piping to 2' above grade with a sealed PVC jacket. All joints shall be sealed watertight. The outer jacket shall be protected with a double layer wrap of 30 pound roofing felt prior to backfill. Care shall be taken during backfill to avoid damage to the insulation and jacket.
- P. Metal Protective Jacket: Protect outer covering of insulation with a metal jacket system over both pipe and fitting insulation where exposed to weather [, where _____] [or where exposed indoors]. Metal jacket shall extend over PVC jacketing or vapor barrier, down to grade at riser locations or building entrance. Longitudinal seals shall provide a 3" overlap installed at the 9 o'clock or 3 o'clock position to shed water. Butt joints shall be overlapped a minimum of 3" in a manner to prevent the entry of water. Seal metal jacketing with 3/4" stainless steel sealing bands shall be installed on 12" centers along the metal jacket. Locate strap joints so as to prevent personnel contact. Metal jacket on valves and flanges shall be removable without disturbing the adjacent jacket.
- Q. Vapor Barrier: Maintain integrity of vapor barrier on chilled water [and all other cold] pipe insulation and protect barrier to prevent puncture and other damage.
- R. Penetrations: Extend piping insulation without interruption through walls, floors, and similar penetrations, except where otherwise indicated. Where insulation is interrupted on chilled water piping, an isolating seal shall be provided between the insulation vapor barrier and the pipe and penetration seal as specified under Paragraph 3.03/D. Where insulation is interrupted on steam and condensate piping, the penetration seal shall be insulated as specified for the penetrating piping, such that no high temperature surfaces are exposed.
- S. Ventilation: Provide adequate ventilation during initial start-up of piping systems to remove smoke and odor given off when the organic binders in the insulation are initially heated.

3.4 DUCTWORK APPLICATION:

- A. Exterior Ductwrap Insulation On [Supply], [Return] [and General Exhaust] Ductwork: After ductwork testing has been completed, insulate [Supply], [Return], [and General Exhaust] ductwork as specified in section 2.5 above. On ducts over 18" wide, apply weld clips to bottom of duct, spaced 18" on center each way, maximum. Seal all longitudinal and transverse seams and all punctures caused by weld clips or stick clips with 2" wide SMACNA-labeled duct tape and mastic.
- B. Acoustical Duct Lining For Supply, Return and General Exhaust Ductwork: Refer to Section 22 31 13 for additional information.
- C. Rigid Ductwork Insulation: Provide rigid external duct insulation where shown on the drawings and for all exposed ductwork in the [] Room. Insulation shall be secured to the ductwork with mechanical fasteners, "stick clips", Graham Pins or Speed Clips spaced on maximum 12" centers on the bottom of the duct and maximum 24" centers on the top and side of the duct. Additional fasteners shall be provided as recommended by the insulation manufacturer or required to hold insulation securely against the duct. After the insulation is in place, all joints, seams and protrusions through the duct shall be thoroughly sealed with Foster 30-35 or approved equal white vapor barrier emulsion applied over 3" wide Duramesh Glass Fabric or approved equal glass fabric strips. Where ductwork has standing seams or external angle bracing, insulation shall be built up over protrusions and sealed as described hereinabove.
- D. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles, cements adhesives, coatings, sealers, protective finishes, and similar compounds as recommended by the insulation manufacturer for the applications indicated.
- E. Air Devices: Insulate all air devices not factory-insulated with fiberglass ductwrap where diffusers are located in ceilings that are not used as return air plenums.
- F. Special Applications: Roof drains and floor drains may be insulated with duct wrap if the Contractor submits and receives approval on his recommended means of maintaining a vapor seal.
- G. **Kitchen Exhaust Ductwork: After duct testing has been completed, apply insulation with joints staggered, to clean dry ductwork surfaces and hold in place with one inch (1") galvanized hexagonal wire mesh with edges laced together. Where necessary to achieve a snug fit of insulation on large surfaces, install weld clips 18" on center to surfaces before installation of insulation and tie to wire mesh with 20 gauge galvanized wire. Insulation will be enclosed in a 2 hour duct enclosure installed under other Divisions.]**
- H. Surfaces: Install insulation materials with smooth, even surfaces.
- I. Butt Joints: Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- J. Vapor Barrier: Maintain integrity of vapor barrier on ductwrap insulation and protect barrier to prevent puncture and other damage.
- K. Penetrations: Extend ductwrap insulation without interruption through walls, floors, and similar ductwork penetrations, except where otherwise indicated.
- L. Corner Angles: Install corner angles on external corners of insulation on ductwrap in exposed finished spaces before covering with jacketing.
- 3.5 INSPECTION:
- A. General: Visually inspect the completed insulation installation and repair or replace any improperly sealed joints.
- B. Wet Insulation: Where there is evidence of vapor barrier failure or "wet" insulation after installation, the damaged insulation shall be removed, the pipe or duct surface shall be cleaned and dried and new insulation shall be installed.
- 3.6 IDENTIFICATION:
- A. Refer to Section 23 03 00 for applicable painting and labeling requirements.

END OF SECTION 23 07 00

SECTION 23 09 10 - LABORATORY AIRFLOW CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

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

1.2 DESCRIPTION OF WORK:

- A. System Description: Provide a Laboratory Airflow Control System (LACS) to control the airflow into and out of laboratory rooms. The exhaust flow rate of a laboratory fume hood shall be precisely controlled to maintain a constant average face velocity into the fume hood. The laboratory control system shall vary the amount of makeup/supply air into the room to operate the rooms at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates, and maintain laboratory pressurization in relation to adjacent spaces (positive or negative). The laboratory airflow control system shall be capable of operating as a stand-alone system and as a system integrated with the existing UH Campus Building Control and Automation System (BCAS).
- B. Control Protocol: Each room in the suite shall be operated as a constant volume occupied/unoccupied mode system with room pressurization via supply/exhaust offset as shown on the drawings. Unoccupied mode shall reduce the room supply air volume by 50% while maintaining pressure control offsets. The unoccupied mode shall be implemented based on time program inputs through the UH Campus system. The system design shall allow for future conversion to VAV operation with a supply air minimum in the future without any hardware changes.
- C. Airflow Device Actuation: Airflow device actuation shall be DDC modulated electric actuation. Electrical power shall be supplied from the building 120 volt power supply.

1.3 QUALITY ASSURANCE:

- A. Venturi controls basis of design shall be Phoenix Lab System Controls. Other venture controls will be considered if the manufacturer can demonstrate attaining similar certification and compliance with UH standards.
- B. Certification: Provide manufacturer's and independent test lab certification of test results, signed by an authorized officer of the company.
- C. Preparation: Laboratory airflow control products to be clean and free of all foreign matter prior to shipping. Units and associated equipment such as controls, shall be packaged in a manner to prevent dust and other foreign matter from entering the unit, controls, and similar items during shipment. All external controls, operators, and sensors shall be covered by rigid metal shields during shipment and storage.
- D. Performance Verification: The laboratory airflow control system supplier shall demonstrate a typical laboratory space that includes multiple fume hoods, a general exhaust, and a supply airflow control device for the purpose of verifying the laboratory airflow control system's ability to meet the performance requirements indicated in this specification. All travel and lodging costs to witness the performance verification shall be the responsibility of the laboratory airflow control system supplier.
- E. Preventive Maintenance: The laboratory airflow control system supplier shall provide at no additional cost to the owner during and after the warranty period, five years of required preventive maintenance on all airflow sensors (e.g., pitot tube, flow cross, orifice ring, air bar, hot wire, vortex shedder, side wall sensors, etc.), and flow transducers provided under this section. Airflow sensors shall be removed, inspected, and cleaned annually during the five year period to prevent inaccuracies due to long term buildup from corrosion, lab tissues, wet or sticky particles, or other materials that foul the sensor. If impractical to remove the airflow sensors, the laboratory airflow control system supplier shall include in the proposal the cost of supplying and installing duct access doors, one for each sensor. The transducer shall be checked and recalibrated annually to insure long-term accuracy. Note that auto-zero recalibration of transducers is not acceptable as a substitute for annual recalibration.

- F. Warranty Period: Warranty shall commence upon the date of shipment and extend for a period of thirty-six months whereupon any defects in materials or laboratory airflow control system performance shall be repaired by the supplier at no cost to the owner.

1.4 SUBMITTALS:

- A. Shop drawing submittals shall include, but not be limited to, the following:
1. The laboratory airflow control system supplier shall provide a detailed proposal describing all elements of the laboratory control system. A schematic layout shall be provided, showing relations of these elements and a description of how they interact.
 2. Technical specification data sheets shall be provided for all proposed system components and devices.
 3. Cut sheets on each all laboratory airflow controls, clearly marked to show sizes, configuration, construction, unique features, controls, clearances, accessories, performance data, sound data, operating sequence and other pertinent information.
 4. Air valve curves or charts which clearly show air valve performance, including air flow sensor calibration curves.
 5. Performance characteristics for each terminal unit.
 6. All proposed airflow control devices shall include discharge, exhaust, and radiated sound power level performance obtained from testing in accordance with ARI Standard 880.
 7. Wiring and control diagrams.
 8. Copies of factory-certified sound, leakage and performance test results from actual tests of units of the same model and construction to those which will be provided for the project.
 9. Written report of the test results including noise criteria (NC) in sound power as tested in reverberant room with terminal unit operating at the scheduled airflow. When reporting NC levels, no credits or reduction shall in any way be considered for room, plenum, ceiling, and similar item effects.
 10. Certified dimensioned drawings showing the locations of all openings, support points, connections, sizes for same, overall dimensions of all boxes and any other pertinent information that may affect the installation of the boxes.
 11. Submit the following certified performance data for each size and type of terminal unit to be used on the project:
 - a. Maximum and minimum cfm ratings at 0.35" discharge static pressure.
 - b. Pressure drop through each primary air damper at 25%, 50% and 100% of design cfm.
 - c. Pressure drop through terminal unit and heating coil at full plenum air mode for fan powered terminal units and full heating and full cooling modes as applicable for single and double duct terminal units.
 - d. Radiated and discharge sound power data for each size terminal unit at 0.5", 1.0", and 1.5" primary duct static pressure, 0%, 25%, 50%, 75% and 100% primary cold air and design discharge cfm (constant fan powered terminal units only) and static pressure.
 - e. Temperature mixing data for each size dual duct terminal unit at maximum and minimum discharge cfm for the unit size with 25%, 50% and 75% primary air.
 12. Product warranties and guarantees.
 13. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver laboratory airflow control systems in bulk containers or factory-fabricated water-resistant packaging.
- B. Handle laboratory airflow control systems carefully to avoid damage to components, enclosures, and finish.

- C. Store laboratory airflow control systems in a clean, dry space and protect from weather until delivery to the site or to the designated contractor..

PART 2 - PRODUCTS

2.1 AIRFLOW CONTROL SYSTEM DESCRIPTION:

- A. Each individual area shall have a dedicated laboratory airflow control system. Each dedicated laboratory airflow control system shall support a minimum of twenty (20) network controlled airflow devices.
- B. The laboratory airflow control system shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood’s exhaust airflow to maintain a constant face velocity over a minimum range of 20% to 100% of sash travel. The corresponding minimum hood exhaust flow turndown ratio shall be 5 to 1.
- C. The hood exhaust airflow control device shall respond to the fume hood sash opening by achieving 90% of its commanded value within one second of the sash reaching 90% of its final position (with no more than 5% overshoot/ undershoot) of required airflow. Rate of sash movement shall be between 1.0 to 1.5 feet per second.
- D. The laboratory airflow control system shall maintain specific airflow (±5% of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change airflow change or quantity of airflow control devices on the manifold (within 0.6" to 3.0" wc)
- E. The laboratory airflow control system shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure. Systems using differential pressure measurement or velocity measurement to control room pressurization are unacceptable.
- F. The laboratory airflow control system shall maintain specific airflow (±5% of signal) with a minimum 16 to 1 turndown to insure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.

2.2 AIRFLOW CONTROL SOUND SPECIFICATIONS:

- A. Unless otherwise specified, the airflow control device shall not exceed the sound power levels in Table 1, Table 2 and Table 3.
- B. If the airflow control device cannot meet the sound power level specification, a properly sized silencer or sound attenuator must be used. All silencers must be of a packless design (constructed of at least 18 gauge 316L stainless steel when used with fume hood exhaust) with a maximum pressure drop at the device’s maximum rated flow rate not to exceed 0.20 inches of water.
- C. All proposed airflow control devices shall include discharge, exhaust and radiated sound power level performance.

Table 1. Exhaust Airflow Control Device Sound Power Level

	Exhaust Sound Power Level in dB (re: 10 ⁻¹² watts)					
Octave Band Number	2	3	4	5	6	7
Center Frequency in Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-50 cfm Device						
800 cfm @ 0.6" wc	63	55	52	54	50	49
200 cfm @ 0.6" wc	46	42	38	37	32	25
800 cfm @ 3.0" wc	73	70	64	66	65	60
200 cfm @ 3.0" wc	51	52	51	50	52	51

1500-100 cfm Device						
1200 cfm @ 0.6" wc	65	58	53	56	52	52
400 cfm @ 0.6" wc	50	45	38	39	37	31
1200 cfm @ 3.0" wc	72	70	62	65	64	60
400 cfm @ 3.0" wc	55	57	55	53	56	55
3000-200 cfm Device						
2400 cfm @ 0.6" wc	63	56	55	58	54	55
800 cfm @ 0.6" wc	51	45	41	42	39	34
2400 cfm @ 3.0" wc	75	71	65	68	67	63
800 cfm @ 3.0" wc	58	58	56	56	59	58

Table 2. Supply Airflow Control Device Sound Power Level (Discharge)

Octave Band Number	Discharge Sound Power Level in dB (re: 10 ⁻¹² watts)					
	2	3	4	5	6	7
Center Frequency in Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-50 cfm Device						
800 cfm @ 0.6" wc	62	57	54	58	54	51
200 cfm @ 0.6" wc	45	46	42	44	40	34
800 cfm @ 3.0" wc	72	71	67	75	72	68
200 cfm @ 3.0" wc	53	56	54	58	56	54
1500-100 cfm Device						
1200 cfm @ 0.6" wc	63	59	55	60	54	53
400 cfm @ 0.6" wc	53	49	44	49	45	39
1200 cfm @ 3.0" wc	72	73	69	77	72	68
400 cfm @ 3.0" wc	58	63	61	63	60	57
3000-200 cfm Device						
2400 cfm @ 0.6" wc	64	60	58	63	56	56
800 cfm @ 0.6" wc	52	48	47	52	46	41
2400 cfm @ 3.0" wc	75	75	72	78	73	70
800 cfm @ 3.0" wc	59	62	62	66	62	60

Table 3. Supply Airflow Control Device Sound Power Level (Radiated)

Octave Band Number	Radiated Sound Power Level in dB (re: 10 ⁻¹² watts)					
	2	3	4	5	6	7
Center Frequency in Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-50 cfm Device						
800 cfm @ 0.6" wc	44	41	45	41	36	34
200 cfm @ 0.6" wc	33	28	31	29	26	20
800 cfm @ 3.0" wc	53	53	56	57	55	53
200 cfm @ 3.0" wc	41	38	41	39	39	37
1500-100 cfm Device						
1200 cfm @ 0.6" wc	47	53	40	42	38	36

400 cfm @ 0.6" wc	35	39	31	34	33	26
1200 cfm @ 3.0" wc	52	60	54	60	59	53
400 cfm @ 3.0" wc	42	44	43	46	46	42
<hr/>						
3000-200 cfm Device						
2400 cfm @ 0.6" wc	58	56	45	47	43	42
800 cfm @ 0.6" wc	45	43	36	39	37	29
2400 cfm @ 3.0" wc	69	68	60	65	63	57
800 cfm @ 3.0" wc	54	53	48	51	50	48

2.3 MATERIALS:

- A. General: Provide Laboratory airflow control systems using standard materials and components designed and constructed as recommended by the system manufacturer and as required for a complete installation in compliance with these Specifications.
- B. Control Calibration:
 - 1. Each airflow control device shall be factory calibrated to the job specific airflow as detailed on the plans and specifications. Each factory calibrated control/measuring device shall be electronically calibrated/characterized at the factory. Calibration shall be included in the product cost or related labor hours. No device shall be installed without verification or certification of accuracy or airflow measurement calibration.
 - 2. A final field verification of accuracy and control stability shall be made by the balancing contractor where so directed by the Owner. Accuracy and performance shall be guaranteed as specified irrespective of field conditions and device inlet conditions.
 - 3. Each airflow control valve shall be individually marked with valve specific factory calibration data by the equipment supplier. As a minimum, data shall include valve tag number, serial or unit number, model number, valve characterization information or field test results, and quality control inspection numbers.
 - 4. A final calibration list (electronic data format) of all settings and test results, in MS-Excel 97 format, shall be provided to the Owner.

2.4 AIRFLOW CONTROL DEVICES – GENERAL:

- A. The airflow control device shall be a venturi valve equal to the Phoenix Controls Low Pressure Accel II Valves installed using manufacturer's drawband clamps.
- B. The airflow control device shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifolded system.
- C. The airflow control device shall maintain accuracy within $\pm 5\%$ of signal over an airflow turndown range of no less than 16 to 1.
- D. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.
- E. The airflow control device shall be constructed of one of the following three types:
 - 1. **Class A** - The airflow control device for non-corrosive airstreams such as supply and general exhaust shall be constructed of 16-gauge aluminum. The device's shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be a spring-grade stainless steel. All shaft bearing surfaces shall be made of a Teflon, or polyester, or PPS (polyphenylene sulfide) composite.
 - a. Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used.

2. **Class B** - The airflow control device for corrosive airstreams such as fume hoods shall have a baked-on corrosion resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring-grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of a Teflon or PPS (polyphenylene sulfide) composite.
- F. For two-position or VAV operation, a pneumatic actuator shall be factory mounted to the valve. Loss of pneumatic main air or control power shall cause normally open valves to fail to maximum position, and normally closed valves to fail to minimum position. Electric actuators that fail in last position are not acceptable when used in fume hood and make-up air control applications. Constant volume valves do not require actuators.
- G. The controller for the airflow control devices shall be microprocessor based and operate using a peer-to-peer control architecture. The room-level airflow control devices shall function as a stand-alone network.
- H. The room-level control network shall utilize a LonTalk communications protocol.
- I. There shall be no reliance on external or building-level control devices to perform room-level control functions. Each laboratory control system shall have the capability of performing; Fume hood control, Pressurization control, Temperature control, Humidity control, and implement Occupancy and Emergency mode control schemes.
- J. The laboratory airflow control systems shall have the option of digital integration with the BMS.
- K. Certification:
 1. Each airflow control device shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of at least $\pm 1\%$ of signal over the entire range of measurement. Electronic airflow control devices shall be further calibrated and their accuracy verified to $\pm 5\%$ of signal at a minimum of forty-eight different airflows across the full operating range of the device.
 2. All airflow control devices shall be individually marked with device specific, factory calibration data. At a minimum, it should include: tag number, serial number, model number, eight point characterization information (for electronic devices), and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation.
- L. Airflow control devices that are not venturi valves, and airflow measuring devices (e.g., pitot tube, flow cross, air bar, orifice ring, vortex shedder, etc.) shall only be acceptable provided they meet all the performance and construction characteristics as stated throughout this specification and:
 1. The airflow control device employs transducers manufactured by Rosemount, Bailey, Bristol, or Foxboro. Accuracy shall be no less than $\pm 0.15\%$ of span (to equal $\pm 5\%$ of signal with a 15 to 1 turndown) over the appropriate full scale range including the combined effects of nonlinearity, hysteresis, repeatability, drift over a one year period, and temperature effect. 316L stainless steel materials shall be provided for all exhaust applications. The use of 304 stainless steel materials shall be provided for all make-up air applications.
 2. Airflow sensors shall be of a multi-point averaging type, 304 stainless steel for all supply and general exhaust applications, 316L stainless steel for all fume hood, canopy, snorkel, and bio-safety cabinet applications. Single point sensors are not acceptable.
 3. Suppliers of airflow control devices or airflow measuring devices requiring minimum duct diameters shall provide revised duct layouts showing the required straight duct runs upstream and downstream of these devices. Coordination drawings reflecting these changes shall be submitted by the supplier of the laboratory airflow control system. In addition, suppliers shall include static pressure loss calculations as part of their submittals. All costs to modify the ductwork, increase fan sizes and horsepower, and all associated electrical changes shall be borne by the laboratory airflow control supplier.

4. Refer to Figure A (at end of Section) for Valve Installation instructions'

2.5 FUME HOOD CONSTANT/VARIABLE VOLUME CONTROLLER

- A. Constant volume fume hood controllers shall be identical to the variable volume controller specified herein except that the controls are set to maintain a constant airflow with minimum flow equal to maximum air flow. Constant volume controllers may be changed to variable volume controllers using only the local controller or the central workstation.
- B. The laboratory control system manufacturer shall supply a fume hood control system to directly measure the area of the fume hood sash opening. The measured sash area shall proportionally control the hood's exhaust airflow in a variable volume mode to maintain a constant face velocity. Hood airflow shall be varied to maintain a constant face velocity over no less than a 5 to 1 change in the sash open area (change in sash position).
- C. Fume hood control system shall respond to and maintain the face velocity set point to insure fume hood containment. Response time shall be less than one second with no more than a 5% of set point overshoot and undershoot when the sash is raised or closed. Sash raise time for this test shall be one second with a 5 to 1 change in sash area.
- D. An approved horizontal and/or vertical sash sensor shall be provided by the lab system supplier as an integral part of the lab air volume control system (single source responsibility) to measure the height of each vertically and/or horizontally moving fume hood sash. The sash sensor shall be an approved method of sash position sensing that has a proven application history. **Through wall pressure sensors are not acceptable.**
- E. A fume hood monitor shall be provided to receive the sash opening signals from the vertical and/or horizontal sash sensors. The monitor shall compute the total open sash area and output an exhaust airflow control signal to the appropriate volume control device (valve) to maintain a constant face velocity.
- F. The fume hood monitor shall modulate the airflow in response to the sash opening signals from the vertical sash sensors between closed and 18" open or the stop set point. Above the stop set point, the exhaust valve shall maintain a constant airflow and allow the face velocity to reduce proportionately to the face opening.
- G. The face velocity and minimum and maximum exhaust flow level of the fume hood shall be set through the fume hood monitor or control. A hand held device shall be provided to the university for each 50 (or fraction thereof) hoods, or labs, if an independent tool is required to adjust settings. Adjustments of the face velocity shall be provided at the minimum and maximum sash positions. Sash sensors shall be provided with an unconditional five (5) year material, labor and calibration warranty.
- H. As an option the owner may select an air flow control system with an emergency exhaust switch mounted on the fume hood monitor, with an audible alarm, which shall override the sash sensor and command maximum exhaust airflow. A dedicated push to start, push to stop, push button switch shall force the hood exhaust volume control device to its full flow position and force the supply valve to it specified minimum position.
- I. Fume hood monitor shall contain a visual and audible alarm to indicate a low face velocity. Muting of the alarm shall only silence the audible portion, while the visual alarm shall be maintained until the low flow condition has returned to normal. Alarm shall be triggered by:
 1. A differential pressure sensor located across a hood exhaust valve or a calibrated airflow measuring station that reports the differential to the control system. The controls will initiate an alarm at an air flow or pressure reduction of approximately 20% (operator adjustable) below air flow set point or design pressure differential.
 2. A difference between the airflow command sent to the hood exhaust valve compared to the actual flow measurement feedback. This type of control will not replace the differential pressure sensor.
 3. The sash being raised above a specified height and or specified area for fume hoods not sized for 100% opening.
 4. The alarm wire being disconnected.

- J. A push button switch shall be provided to mute the audible alarms. The mute mode is automatically reset when the alarm condition ceases.
- K. In labs without fume hoods, a lab emergency push button (equipment and control option) may be installed at the exit to the lab. Switch shall activate all exhaust and supply valves causing the exhaust and supply system to flush the lab and sound an audible alarm to signal lab emergency condition.

2.6 INDIVIDUAL ROOM AIRFLOW CONTROL UNITS:

- A. Provide a room airflow control or control panel for **each room to control the airflow balance of that room**. The room Airflow Control Unit shall be panel mounted in the location shown on the drawings to provide ease of maintenance. Provide one room Airflow Control Unit per controlled room.
- B. The output from the room's temperature sensor, in response to the space temperature, will cause the dual duct dampers to modulate independent of the room volume control.
- C. The control signal for the make-up/supply air flow control valve shall be generated by the required offset and the difference between the supply air flow and the total general exhaust or auxiliary and hood exhaust valve air signals. The controls shall cause the supply to modulate with the exhaust total to maintain a **stable room pressurization differential (offset)**. **The controls shall maintain a stable offset airflow to prevent the room from changing pressure relationships during variable airflow and during hood sash movement.**
- D. The individual room controls shall sense the room temperature and the mixing damper position. Air flow shall be increased only when the mixing dampers are at their limit with all flow through the hot deck or the cold deck.
- E. The room Airflow Control Unit shall increase flow at the general exhaust valve or auxiliary exhaust valve under conditions where additional exhaust is required to maintain the room's airflow balance and temperature. The general exhaust valve command shall equal the difference between the supply volume requirement for temperature control and the hood's make-up air volume. Control of the general exhaust valve directly by the thermostat, with the supply volume equal to the sum of the general and hood exhaust volumes less offset **is not allowed**.
- F. The Airflow Control Unit shall sum the hood exhaust and general exhaust volume signals and output a linear scaled control signal representing the total exhaust volume.
- G. The Airflow Control Unit shall be electronic or a DDC microprocessor-based digital controller. The controller shall control and communicate digitally via a high speed Peer to Peer digital network. A polling sub-LAN network requiring a primary controller to provide communication and distribution of information between the secondary lab controllers is not acceptable. The inputs shall accept signals proportional to general, auxiliary, fume hood, exhaust, and space supply flows. The output signals shall control supply valves, general exhaust/return air valves, with signals proportional to the desired supply or exhaust volumes.
- H. Integral field adjustable controls shall be provided for all required calibration and scaling adjustments. Where direct airflow measurement is used for this control, each sensor utilized must have the capacity of being field validated with individual zero and span calibrations. Autozero routines that use or modulate the damper position are not acceptable. Autozero routines shall limit controls for less than one second and shall be prohibited during sash movement.
- I. The Airflow Control Unit shall maintain a variable negative or positive offset as scheduled on the lab airflow schedule between the sum of the room's total exhaust and the make-up/supply air volumes. This offset represents the volume of air that will enter or exit the room from the corridor or adjacent rooms.
- J. The Airflow Control Unit shall generate signals to represent all airflow sources, sash sensors, and flow alarms. The alarm signals shall be transmitted to the central monitoring system and programmed as a point in the facilities Direct Digital Control/Energy Management System schematic. As a minimum, the following signals (points) shall be monitored at the network interface and scheduled as a data point in the facilities Direct Digital Control/Energy Management System schematic. This installer shall enter these points on a system schematic before each room is turned over to the owner.

1. Fume Hood Exhaust Flow (CFM)
2. Fume Hood Exhaust Low Flow Alarm.
3. Fume Hood Sash Position.
4. General Exhaust Flow (CFM)
5. Exhaust Flow Alarm
6. Supply/Make-up Airflow (CFM)
7. Supply/Make-up Airflow Alarm
8. Room Temperature
9. Room Offset (CFM)
10. Room Temperature Setpoint
11. Room Offset Setpoint (CFM)
12. Total Room Exhaust Flow (CFM)
13. Total Room Supply Flow (CFM)

- K. A power supply for the control panel mounted unit, shall be included to power the laboratory airflow control system from one dedicated 120 VAC line connection per interface panel.

2.7 EXHAUST AND SUPPLY AIRFLOW DEVICE CONTROLLER:

- A. The airflow control device shall be a microprocessor-based design and, shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.
- B. The airflow control device shall store its control algorithms in non-volatile, re-writable memory. The device shall be able to stand-alone or to be networked with other room level digital airflow control devices using an industry standard protocol.
- C. Room-level control functions shall be embedded in and carried out by the airflow device controller using a distributed control architecture. Critical control functions shall be implemented locally, no room-level controller shall be required.
- D. The airflow control device shall use industry standard 24 Vac power.
- E. The airflow control device shall have provisions to connect a notebook PC commissioning tool and every node on the network shall be accessible from any point in the system.
- F. The airflow control device shall have built-integral Input/Output connections address fume hood control, temperature control, humidity control occupancy control, emergency control and non-network sensors switches and control devices. At a minimum the airflow controller shall have:
 1. Three (3) Universal Inputs, capable of accepting 0 to 10Vdc, 4 to 20mA, 0 to 65k ohms, or Type 2 or Type 3 10k ohm @ 25 degree C thermistor temperature sensors.
 2. One (1) Digital Input capable of accepting a dry contact or logic level signal input.
 3. Two (2) Analog Outputs capable of developing either a 0 to 10Vdc, or 4 to 20mA linear control signal.
 4. One (1) Form C (SPDT) relay output capable of driving up to 1A @ 24Vac/Vdc.
- G. The airflow control device shall meet FCC Part 15 Subpart J Class A, and be UL916 listed.

2.8 SUPPLY AND EXHAUST TERMINAL UNITS/AIRFLOW DEVICES GENERAL:

- A. General Performance: Devices using mechanical CFM limiters will not be accepted, nor shall it be necessary to change control components to make airflow rate changes or change from constant volume operation to variable volume operation. Where used, electric actuator motors, electronic controllers, and electronic or DDC controls shall be furnished, mounted and adjusted by the laboratory airflow controls manufacturer to assure their proper placement within the units. The manufacturer shall be responsible for the construction of the terminal unit, the installation of internal control components,

all workmanship and materials of the entire assembly of unit and controls and shall be responsible for the performance of the controls.

B. Control Performance:

1. Project lab air controls shall be designed to operate initially as a constant volume occupied/unoccupied room with the ability to change to variable volume room operation at a future date.
2. Supply unit assemblies shall modulate cold and hot air to maintain space temperature. An independent volume controller downstream of the dual duct assembly shall provide volume control as specified hereinafter.
3. General exhaust valves shall respond to the hood exhaust valve flow to maintain the room airflow offset when the hood sash is moved or repositioned. The auxiliary valve or room exhaust valve shall also modulate (in a VAV mode) to maintain the air flow as low as possible within the temperature and air change or air flow limits set for "occupied" and "unoccupied" conditions.
4. The supply air volume controller shall modulate to provide a stable, constant, room offset (exhaust less supply CFM).

C. Electric Control Operators, Sensors and Related Materials:

1. Field pneumatic control air connections by the Contractor shall consist of air connections to the riser and all distribution within and to the room, if required, for electric operators, sensors and related components. All control logic shall be electronic. The dual duct box manufacturer shall install all airflow monitoring tubing between the heating and cooling sides of the assembly required for operation. A calibration chart and piping diagram shall be submitted for approval. A copy of the approved wiring diagram shall be attached to the side of the unit near the cold duct valve.
2. To provide for a safe airflow in the event of power failure, the units are to be arranged so that supply airflow control dampers fail closed (normal position).
3. All electrical work and products shall meet Division 26 requirements..

2.9 TWO-POSITION EXHAUST AIRFLOW CONTROL DEVICES:

- A. The airflow control device shall maintain a factory calibrated fixed maximum and minimum flow setpoint based on a switched electronic signal. Two-position devices requiring feedback shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow. All Two-Position devices shall either be networks, or hard-wired into the room-level network so as to be considered under pressurization control.

2.10 CONSTANT VOLUME AIRFLOW CONTROL DEVICES:

- A. The airflow control device shall maintain a constant airflow setpoint. It shall be factory calibrated and set for the desired airflow. It shall also be capable of field adjustment for future changes in desired airflow.
- B. Laboratory airflow control systems suppliers not employing constant volume venturi airflow control valves shall provide electrical wiring as required for their devices.

2.11 CONSTANT AND VARIABLE VOLUME EXHAUST TERMINAL UNITS/AIRFLOW CONTROL VALVES:

- A. Constant volume exhaust controllers shall be identical to the variable volume controller specified herein except that the controls are set to maintain a constant airflow with minimum flow equal to maximum airflow. Constant volume controllers may be changed to variable volume controllers using only the local controller or the central workstation.
- B. All airflow control valves shall provide smooth accurate fast response to the control signals. Valve shall be constructed such that the control valve and damper insure a minimum static pressure loss. Valve shall provide accurate control at low flow values.

- C. Valve shall be pressure independent over a 0.3" to 4.0" WC drop across the valve. Integral pressure independent assembly shall respond and maintain specific airflow within two seconds of a change in duct static pressure.
- D. Valve airflow measurement shall use the flow measurement and control valve described in the dual duct device above with the following criteria or:
 - 1. General exhaust air valves shall use the multi port flow measurement device described above for the dual duct device or the orifice plate described below. The multi port flow measurement device shall maintain accuracy over a minimum turn down ratio of 5:1 when designed for a maximum flow pressure drop of 0.3" WG.
 - 2. The general exhaust air valve shall be suitable for use as a Hood exhaust air valve or as an general/auxiliary exhaust valve with a design flow of 75% of it's initial selection air flow and a 5:1 turndown from the reduced air volume.
 - 3. Hood exhaust valve bodies and assemblies shall use a calibrated orifice plate flow station designed for the airflow velocities scheduled or recommended for each application when selected for a design flow pressure drop of 0.3" WG. The orifice shall maintain accuracy over a minimum turn down ratio of 5:1.
- E. Airflow accuracy shall be a maximum of $\pm 5\%$ of reading (not full scale) regardless of inlet or exit duct configuration over an airflow turndown range of not less than 5 to 1 with an initial design pressure differential of 0.30" static pressure drop across the measure/control device. No entrance or exit duct diameters (other than size transitions) shall be required to ensure speed of response, accuracy, or pressure independence. Where straight duct or a size transition is required, the manufacturer shall provide integral to the equipment supplied, straightening vanes and duct sections to accommodate the entrance/exit requirements and ensure performance.
- F. Valve shall be constructed of one of the following two types:
 - 1. General exhaust air valve bodies shall be constructed of 16 gauge aluminum or 18 gauge galvanized steel. All bearing surfaces shall be long life teflon or teflon infused. The valve's shaft, pivot arm, shaft support brackets, and internal mounting hardware shall be made of 316L Stainless Steel. Supply air valve may be integral to the dual duct assembly.
 - 2. Hood cabinet exhaust valve bodies and assemblies shall have two baked-on coats of corrosion resistant phenolic coating (Heresite P403) or shall be constructed entirely of 316L Stainless Steel. The valve components located in the air stream shall be 316L Stainless Steel. The pivot arm, shaft support brackets, and internal mounting hardware shall be made of 316L Stainless Steel. General 300 Series Stainless Steel materials are unacceptable.
- G. A pneumatic actuator shall be factory mounted to the valve body to vary the position of the valve cone/damper from its minimum to maximum flows. Loss of control power or pneumatic supply air shall cause hood exhaust valves to fail open, general exhaust valves to fail open, auxiliary valves to fail closed and supply valves to fail closed (verify with each lab).

2.12 DUAL DUCT/AIR VALVE SUPPLY TERMINAL UNITS:

A. Casing Construction:

- 1. The units shall be constructed of a minimum of 22 gauge galvanized steel, double walled, insulated with a minimum of R-10 insulation. Provide hanger tabs to prevent hanging from the bottom of the housing. The insulation shall be sealed between the two walls with all edges and seams sealed or "captured", encapsulating all fibers of the insulation. The interior wall shall be neatly installed with no rough edges to interrupt the smooth flow of air through the box. The casing shall be insulated throughout its interior. On manufactured units with separate volume control valves, provide 1 ½" thick foil faced fiberglass duct wrap installed per manufacturer's recommendations on the volume control valve.
- 2. All interior features of the boxes (such as mixing baffles (if required), damper housings, etc.) shall be secured within the casing to avoid excessive movement or rattling with air movement or externally generated vibration. All external features of the terminal units shall be designed not to extend beyond the edges or sides of the unit. (For example, the actuator mounting brackets, etc.

shall not extend beyond the plane of the inlet "bulkhead.") The only exception shall be flow sensors installed in the inlet duct connections. Note that if a separate flow station is installed within a frame within the casing, then it shall be so installed not to allow airflow to bypass the flow measurement station.

3. The terminal units shall be constructed with round inlet and discharge ductwork connections. The inlet ductwork connections shall extend a minimum of 4 inches from the unit casing including an allowance for the installation of airflow station(s) or probe(s). The round connections shall include 1" extension with flanged or metal, lever action, draw band, quick connectors for use by the contractor to secure the discharge ductwork or appurtenances to the unit and shall be reinforced to provide a rigid assembly.
- B. **Casing Leakage:** Assembled units shall be so constructed and sealed to limit air leakage to the following listed quantities at 4" static pressure. Leakage curves or tables will be required as part of the submittal data. The following is the maximum allowable CFM (unless otherwise scheduled) and casing leakage including all components:

<u>Diameter</u>	<u>Maximum Allowed CFM (Area x 2000 fpm)</u>	<u>Maximum Allowable CFM Casing Leakage</u>
4"-5"-6"	393	8.0
7"-8"	698	14.0
9"-10"	1091	22.0
11"-12"	1571	30.0

- C. **Access Doors:** On double duct boxes, provide an access door (12" x 12") immediately downstream of the dampers for inspection, service and cleaning of the interior. If the damper assembly is easily removed from the rear of the box, the access size can be reduced to 8" round or 8" x 8" for inspection and cleaning only. Provide access door as manufactured by Ventlock, Flexmaster Inspector, Ward or equal.
- D. **Mixing Damper Construction:** The damper blades shall be a minimum of 22 gauge galvanized steel or equal aluminum and shall be securely riveted or bolted through the damper shafts to assure no slippage of the blades. The damper shafts shall operate in rust-proof, self-lubricating bearings. Damper shafts penetrating the unit casings shall be sealed against leakage, and bearings shall be installed for protection against wear in the casing penetration. Damper shafts shall be formed of, or cut from solid stock; no hollow shafts will be allowed. The dampers shall seat against gasketed stops or the dampers shall have gasketed edges. Gaskets shall be mechanically fastened to the blades. If the fastening method is not full contact clamping type, then the addition of adhesive to the gasket shall be required. The dampers shall be so constructed to prevent "oil canning" of the damper blade. The units shall be tested for leakage in both inlets with 6" static pressure imposed on one inlet at a time. The maximum percent leakage from all tests shall be reported. Leakage curves as a function of pressure shall be supplied as part of the submittal data. The damper actuator linkage, if used, shall be constructed of material of sufficient strength to avoid buckling under extreme loads. Also, linkages shall not allow play greater than 5 degrees of damper movement. The controls for the dampers shall cause the dampers to fail to the closed position unless specifically noted otherwise on the design documents.
- E. **Unit Pressure Drop:** For all units the static pressure across the assembly at design flow shall not exceed 0.45 inches water gauge, with the total flow through either inlet.
- F. **Certification:** The Unit Manufacturer shall certify (individual device testing is not required) that each unit used on this project will perform as specified. Each unit shall bear a tag or decal listing the following specified information:
 - a. Rated Pressure
 - b. Leakage CFM (casing)
 - c. Date of Mfg.
 - e) Unit Tag Number
 - f) Unit size - 6", 8", etc
 - g) Calibrated CFM, ie 800 CFM Max

- G. Mixing: Dual duct terminal units serving multiple spaces shall provide mixing within the units, and not rely upon the discharge ductwork to provide for the total mixing process. The horizontal average temperature of the air as it leaves the terminal unit shall not vary more than 5°F for each 20°F of temperature difference between the two inlet air supplies. (For example, if the cold supply air is 59°F and the hot supply air is 79°F., the difference is 20 degrees. The allowable temperature variation of the discharge air is, thus, 5°F.) The temperature of the discharge air shall be measured on randomly selected field units by the owner's TAB consultant using three evenly spaced vertical and horizontal rows.
- H. Constant Volume Terminal Units: Constant volume supply terminal units shall be identical to the variable volume terminal units except that the controls are set to maintain a constant airflow with minimum flow equal to maximum airflow. Constant volume controllers shall be capable of 2 position occupied/unoccupied operation and shall be field convertible to variable volume controllers using only the local controller interface or the central workstation.
- I. Flow Measurement and Control:
1. Airflow measurement and pressure independent control shall be accomplished by the use of one or more factory calibrated, pressure independent venturi air valves with electronically modulated pneumatic operators.
 2. The control logic shall use the factory calibrated NIST traceable calibration to measure the airflow.
 3. The airflow control and measuring device shall be designed to prevent signal degradation due to dirt or dust in the air stream.
 4. On all systems, sensors shall be mounted as required by the laboratory airflow controls supplier.
 5. Sensors shall be designed and manufactured such that inlet conditions do not reduce the accuracy or repeatability of the sensor and related control. Where straight duct is required, the manufacturer shall provide integral to the equipment supplied, straightening vanes and duct sections to accommodate the entrance requirements.
 6. Control system shall be such that overshoot will be limited to three percent of the desired control volume under any condition.
 7. Control system shall be such that control hunting will be limited to hunting of between 1% and 5% of set point CFM for a maximum of three seconds after the sash movement stops or a flow reset is established under any condition.
 8. Control system shall be such that control hunting of the lab offset will be limit hunting to prevent any lab from becoming positive due to sash movement or heat load changes in the lab.
 9. Lab controls and individual devices shall be capable of a minimum of 5/1 turndowns as described herein.

2.13 CONTROL FUNCTIONS

- A. General: The airflow control devices shall utilize a peer-to-peer, distributed control architecture to perform room-level control functions. Master/Slave control schemes shall not be acceptable. Control functions shall at a minimum include, pressurization, temperature, humidity control and respond to occupancy and emergency control commands.
- B. Pressurization Control:
1. The laboratory control system shall control supply and auxiliary exhaust airflow devices in order to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure. This offset shall be field adjustable and represents the volume of air, which will enter (or exit) the room from the corridor or adjacent spaces.
 2. The pressurization control algorithm shall sum the flow values of all Supply and Exhaust airflow devices and command appropriate controlled devices to new set points to maintain the desired offset. The offset shall be adjustable.
 3. The pressurization control algorithm shall consider both networked devices, as well as:

- a. Up to three (3) non-networked devices providing a linear analog flow signal.
 - b. Any number of Constant Volume devices where the total of supply devices and the total of exhaust devices may be factored into the pressurization control algorithm.
 4. Volumetric offset shall be the only acceptable means of controlling room pressurization. Systems that rely on differential pressure as a means of control shall provide documentation to demonstrate that space pressurization can be maintained if fume hood sashes are changed at the same time a door to the space is opened.
 5. The Pressurization control algorithm shall support the ability to regulate the distribution of total supply flow across multiple supply airflow control devices in order to optimize air distribution in the space.
- C. Temperature Control:
1. The laboratory control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. The laboratory control system shall support up to four separate temperature zones for each pressurization zone. Each zone shall have provisions for monitoring up to five (5) temperature inputs and calculating a straight-line average to be used for control purposes. Separate cooling and heating set points shall be writable from the BMS, with the option of a local offset adjustment.
 2. Temperature control shall be implemented through the use of independent primary cooling and heating control functions, as well as an auxiliary temperature control function, which may be used for either supplemental cooling or heating. Cooling shall be provided as a function of thermal override of conditioned air with both supply and exhaust airflow devices responding simultaneously so as to maintain the desired offset. Heating shall be provided through modulating control of a properly sized reheat coil.
 3. The laboratory control system shall also provide the built-in capability for being configured for Hot Deck/Cold Deck temperature control.
 4. The auxiliary temperature control function shall offer the option of either heating or cooling mode and to operate as either a stand-alone temperature control loop, or staged to supplement the corresponding primary temperature control loop.
- D. Humidity Control: The Laboratory control system shall have an embedded humidity control function, which allows the monitoring and control of the relative humidity level in the pressurized zone. Using peer-to-peer control, the airflow devices shall have the ability to monitor the relative humidity level of the space and, based on a BMS writable set point, develop a control signal to drive one or the other humidification or dehumidification control circuits. The humidity control loop(s) shall share a common set point, with a configurable deadband adjustment to prevent the humidification and dehumidification control functions to operate at the same time.
- E. Occupancy Control: The laboratory control system shall have the ability to change the minimum ventilation and/or temperature control set points, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state may be set by either the BMS, as a scheduled event, or through the use of a local occupancy sensor or switch. The laboratory control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied, for a predetermined interval. The override interval shall be configurable for 1 to 1,440 minutes. The local occupancy sensor/switch, or bypass button shall be given priority over a BMS command.
- F. Local Alarm Control: The laboratory control system shall provide the means of summing selective alarm activity at the room-level network and generating a local alarm signal. The local alarm signal may be directed to any available output, as well as to the BMS. The alarm mask may be configured differently for each room-level system.
- G. Fume Hood Control: Airflow devices intended to control the face velocity of a fume hood, shall have the ability to interface directly with the Fume Hood Monitoring device. The airflow control device shall:

1. Accept command inputs to regulate the flow accordingly and make this command value available to the BMS.
 2. Accept a Sash Position signal and make this value available to the BMS.
 3. Provide a flow feedback signal to the Fume Hood Monitor, which may be used for calculating face velocity, or to confirm the airflow device has achieved the proper flow rate and make this value available to the BMS.
 4. Provide alarm signals to the Fume Hood Monitor in the event the airflow device is unable to achieve the proper flow rate, or there is a loss of static pressure indicating improper fan operation, or that there is a loss of power to the airflow control device, in order to provide a local alarm indication.
- H. The fume hood airflow control device shall respond to changes in sash position and user presence within 1 second, in order to provide a constant 100 feet per minute face velocity when the fume hood is in use.
- I. The laboratory control system shall be segregated into individual sub nets to isolate network communications to insure room-level control functions and BMS communications may be carried out reliably. Each laboratory space, or pressurization zone shall be it's own sub net. Commercially available routers shall be used to provide this isolation.
- J. The laboratory airflow control system shall support at least 20-networked devices in each pressurized zone.
- K. All points shall be available through the interface to the building management system (BMS) for trending, archiving, graphics, alarm notification, and status reports. Laboratory airflow control system performance (speed, stability, and accuracy) shall be unaffected by the quantity of points being monitored, processed, or controlled.
- L. Refer to the BMS specification for the required input/output summary for the necessary points to be monitored and/or controlled.

2.14 INTERFACE TO BUILDING AUTOMATION AND CONTROL SYSTEMS

- A. The laboratory airflow control system network shall digitally interfacing with the MSB Johnson Controls MetaSys system (BCAS) using a venturi valve interface. The required software interface drivers shall be developed and housed in a Gateway, a dedicated interface device furnished by the laboratory airflow control system supplier.
- B. Any or all room-level points shall be available to the BMS for monitoring or trending. The Gateway shall maintain a cache of all points to be monitored by the BMS. The room-level airflow control devices shall update this cache continually.
- C. The building-level network shall be a high-speed LonTalk (1.25 mbps) communications protocol. The building-level network shall support up to one hundred (100) sub nets, or pressurization zones, or six thousand (6,000) data points.
- D. A commercially available interface card shall be provided with the Accel-Way in order to connect to the building-level network.
- E. A commercially available network interface card shall be provided with the Accel-Way to interface with the BMS.

3.1 TEMPERATURE AND HUMIDITY SENSORS:

- A. General: Venturi controls standard room temperature sensors (with LCD readout) and humidity sensors shall be provided to provide control inputs to the laboratory control system.

3.2 ROOM DIFFERENTIAL PRESSURE ALARM PANELS:

- A. General: The venturi controls manufacturer's room monitors shall be provided as shown on the drawings to provide individual room pressure differential monitoring and alarms. Room alarm panels shall also be connected to alarm when a system failure condition which affects the room is detected by the laboratory control system.

3.3 CONTROL WIRING:

- A. General: All wiring required for a complete and operational laboratory control system shall be provided by under this Section.
- B. All line voltage control wiring and all low voltage control wiring and the main data communications loop shall be installed in conduit.
- C. Minimum requirements for control wiring shall be as follows:
 - 1. Control wiring for digital functions shall be No. 18 AWG copper minimum, with 600 volt insulation. Multi-conductor wire shall have an outer jacket of polyvinyl chloride (PVC) or UL listed plenum rated jacket.
 - 2. Control wiring for analog functions shall be No. 18 AWG copper minimum, with 600 volt insulation, twisted and shielded, 2-, 3- or 4-wire to match analog function hardware. Multi-conductor wire shall have an outer jacket of PVC or UL listed plenum rated jacket.
 - 3. Sensor wiring shall be No. 18 AWG copper minimum, twisted and shielded, 2-, 3- or 4-wire to match analog function hardware. Multiconductor wire shall have an outer jacket of PVC or UL listed plenum rated jacket.
 - 4. Class 2 low energy conductor sizes specified for digital and analog functions shall take precedence over any requirements for Class2 low energy remote control and signal circuit conductors specified elsewhere, unless a larger conductor size is required by the NEC.
- D. Line and low voltage control wiring shall not be installed in the same conduit and control wiring shall not be installed in the same conduit with power wiring.
- E. All conduit in shall be run in a neat manner and shall be perpendicular and parallel to building lines. Coordinate conduit routing with field conditions so as not to interfere with code clearances, maintenance access and walkways.
- F. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.
- G. Label or code each field wire at each end. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
- H. Refer to applicable Division 16 Sections for additional requirements for conduit and wiring materials and installation. All conduit and wiring shall be installed in accordance with all requirements of applicable codes.

PART 3 – EXECUTION

3.4 INSTALLATION

- A. The laboratory controls contractor (LCC) shall install the sash sensors, interface boxes, presence and motion sensor, and fume hood monitor on the fume hood. Reel-type sash sensors and their stainless steel cables shall be hidden from view. Bar-type sash sensors shall be affixed to the individual sash panels. Sash interface boxes with interface cards shall be mounted in an accessible location.
- B. The LCC shall install all Routers and Repeaters in an accessible location in or around the designated laboratory room.
- C. The LCC shall install an appropriately sized and fused 24 Vac transformer suitable for NEC Class II wiring.
- D. All cable shall be furnished and installed by the LCC contractor. The LCC contractor shall terminate and connect all cables as required.
- E. The mechanical contractor shall install all airflow control devices in the ductwork and shall connect all airflow control valve linkages.
- F. The mechanical contractor shall provide and install all reheat coils and transitions.
- G. The mechanical contractor shall provide and install insulation as required.
- H. Each pressurization zone shall have either a dedicated, single-phase primary circuit or a secondary circuit disconnect.

- I. The LCC shall provide point monitoring and make available in the BACnet standard protocol.
 1. Makeup/Supply Air Flow
 2. Makeup/Low Flow Air Alarm
 3. General Exhaust Air Flow
 4. General Exhaust Air Alarm
 5. Fume Hood Flow
 6. Fume Hood Flow Alarm
 7. Fume Hood Sash % Open
 8. Fume Hood Emergency Override
 9. Room Offset
 10. Room Offset Setpoint
 11. Room Temperature
 12. Room Humidity
 13. Room Temperature Setpoint
 14. Reheat Valve Command

3.5 INSTALLATION PRACTICES:

- A. Manufacturer's Instructions: Install system and materials in accordance with manufacturer's instructions, roughing-in drawings and details on the Drawings. All components and appurtenances shall be installed in accordance with the manufacturer's instructions and as shown or specified. All necessary interconnections, services and adjustments required to prepare the system for interface to the Division 23 Building Controls and Automation System shall be furnished. All electrical work shall be in accordance with NEC and current UH standards. Instrumentation grounding as necessary to preclude ground loops and noise from adversely affecting equipment operations shall be installed. Specially trained personnel in the direct employ of the lab airflow controls supplier shall perform final adjustment.
- B. Terminal Unit Locations: Locate each unit accurately in the position indicated in relation to other work. Position unit with sufficient clearance for normal service and maintenance, including clearance for cabinet removal.
- C. Terminal Unit Supports: Minimum support requirements for terminal units shall be as follows. Terminal units weighing less than 150 pounds shall be supported by four 16 gauge, one inch (1") wide sheet metal straps with ends turned under bottom of unit at corners and secured by two maximum 3/4" long by 1/4" diameter sheet metal screw per strap. The other strap end shall be attached to the structure by 1/4" diameter threaded bolt into the concrete insert or into drilled-hole threaded concrete expansion anchor. Boxes over 150 pounds in weight shall be supported the same as described above except 1/4" diameter sheet metal screws shall be located with one screw on the side of the unit and one screw on the bottom of the unit. Seal all screw penetrations into the terminal unit air stream.
- D. Terminal Unit Leveling: Level terminal units to the tolerances recommended by the manufacturer.
- E. Electrical Wiring: Power (120 V, 60 Hz) will be provided at the control panel locations shown on the drawings. Electrical distribution from those locations shall be the responsibility of this equipment supplier/installer.
- F. Raceways: All line and low voltage power and control wiring shall be installed in a raceway or conduit.
- G. Mechanical Work: The installation contractor for the overall lab air distribution systems will receive and install the air flow control equipment (general exhaust air valves, dual duct terminal units and hood exhaust valves). All control installation, calibration, equipment installation review and related electrical system installation shall be by this equipment supplier/installer.
- H. Installation: All automation materials shall be applied and installed per the manufacturers' recommendations.

- I. Pressure Sensors/Transducers: Pressure sensors/transducers (all types) installed in this system shall be installed by this equipment contractor. All pressure sensors shall have taps for calibration. Pressure sensors/transducers shall be verified by calibration. This equipment contractor shall calibrate differential pressure sensors/ transducers. All devices shall be as submitted for and approved during final tests by EAB.
- J. Hood Sash Position Sensors: Sensor type and mounting by this equipment supplier, on existing hoods, shall be properly suited for those existing hood applications to provide reliable operation.
- K. Electrical Wiring: Refer to the applicable Section of Division 16 for electrical wiring incidental to the pneumatic temperature control system regardless of where shown on the Drawings.
1. All conduit, wiring, accessories and wiring connections required for the installation of the Laboratory Control System (LCS), as herein specified, shall be provided by the Laboratory Control System Contractor unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 and all local and national electric codes, unless specified otherwise in this section.
 2. All LCS wiring materials and installation methods shall comply with BCAS manufacturer recommendations.
 3. The sizing type and provision of cable, conduit and trunking shall be the design responsibility of the LCS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, trunking and/or conduit by the LCS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.
 4. Class 2 Wiring:
 - a. All Class 2 (24 VAC or less) wiring shall be installed in conduit.
 - b. Class 2 signal wiring and 24 VAC power can be run in the same conduit. Power wiring 120 VAC and greater cannot share the same conduit with Class 2 signal wiring.
 5. Perform circuit tests using qualified personnel only. Provide necessary instruments and equipment to demonstrate that:
 - a. All circuits are continuous and free from short circuits and grounds.
 - b. All circuits are free from unspecified grounds; that resistance to ground of all circuits is no less than 50 megaohms.
 - c. All circuits are free from induced voltages.
 6. Provide complete testing for all cables used under this Contract. Provide all equipment, tools, and personnel as necessary to conduct these tests.
 7. Provide for complete grounding of all signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops
- L. LCS Raceways:
1. All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 3/4".
 2. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Engineer.
 3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
 4. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.
- M. Penetrations:
1. Provide firestopping for all penetrations used by dedicated LCS conduits and raceways. All other project firestopping to be by other trade.

2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
3. All wiring passing through penetrations, including walls, shall be in conduit or enclosed raceway.
4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.
5. No penetrations in structural elements shall be made before receipt of written approval from the Engineer.

N. LCS Identification Standards:

1. Refer to Section 23 03 00 for additional painting, nameplates and labeling requirements.
2. Node Identification. All nodes shall be identified by a permanent label fastened to the outside of the enclosure. Labels shall be suitable for the node location.
3. Cable Identification: Cable shall be labeled at a minimum of every 18" with the LCS System manufacturer's name and the type of signal carried within the cable, i.e. Analog Input, Analog Output, Binary Input, Binary Output, 24 VAC.
4. Color Coding: Each of the cable types shall be of a different color coding for easy identification and troubleshooting. Color coding to match existing LCS color coding in the MSB.
5. Raceway Identification. All the covers to junction and pull boxes of the LCS raceways shall be painted with the appropriate color.
6. Wire Identification. All low and line voltage LCS wiring shall be identified by a number, as referenced to the associated shop drawing and as-built drawing, at each end of the conductor or cable. Identification number shall be permanently secured to the conductor or cable and shall be typed.

3.6 SYSTEM START-UP AND COMMISSIONING:

- A. General: System start-up shall be provided by a factory-authorized representative of the laboratory airflow control system manufacturer. Start-up shall include calibrating the fume hood monitor and any combination sash sensing equipment as required. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, make-up, general exhaust, or return), system programming and integration to BMS (when applicable).
- B. Adjustment: After completion of the installation, adjust control valves and similar equipment provided as work of this Section. Final adjustment shall be performed by specially trained personnel in the direct employ of the manufacturer of the primary temperature control system.
- C. Fully commission all aspects of the Laboratory Control System work.
- D. The TAB Consultant shall be responsible for final verification and reporting of all airflows.
- E. Acceptance Check Sheet:
 1. Prepare a check sheet that includes all points for all functions of the Laboratory Airflow Control System (LACS).
 2. Submit the check sheet to the Engineer for approval one month prior to testing.
 3. Complete the check sheet for all items and functions of the LACS and initial each entry with time/date as record of having fully calibrated and tested the LACS. Submit to Engineer.
 4. The TAB Consultant will use the check sheet as the basis for acceptance testing with the LACS Contractor.
- F. Provide all necessary specialist labor, materials and tools to demonstrate to the Engineer/ TAB Consultant that the LACS has been commissioned and is operating in compliance with the contract. Prepare a list of noted deficiencies signed by both the Engineer/ TAB Consultant and the LACS Contractor.
- G. Promptly rectify all listed deficiencies and submit to the Engineer/ TAB Consultant that this has been done.
- H. The Engineer/ TAB Consultant will retest the deficiencies in conjunction with the LACS Contractor.

- I. Documentation: Provide all test and calibration data in a complete manual to the Owner for use during final commissioning of the project and whenever lab remodeling is required in the future.

3.7 ANTICIPATED TESTING BY TAB CONSULTANT:

- A. General: As a minimum, TAB Consultant will test a sample room system (supply, hood exhaust and general exhaust) under the following conditions to verify the noted requirements.
 1. Casing leakage rates per the specified maximum leakage per device.
 2. Inlet damper leakage rates per the specified maximum leakage per device.
 3. Unit pressure drop at design flow rates not to exceed the specified limits.
 4. Auto zero function where applicable.
 5. Flow measurement accuracy must be within 5%.
 6. Operation with fittings at the equipment connection.
 7. Overshoot after transient operation shall be limited to 5% of control volume.
 8. Control hunting limited to 5% of set point for a maximum of three seconds.
 9. Verification that the controls do not allow the lab to become negative at any time during or following transient operation.
 10. Verification of stable operation at a 5:1 turndown ratio.
 11. Minimum controllable airflow rates for the devices tested.
 12. Control stability over the test duration.
 13. Full flow tracking during transient airflow and changing cooling and heating loads.

3.8 SYSTEM TRAINING:

- A. The laboratory airflow control system supplier shall furnish a minimum of eight hours of owner training by factory trained and certified personnel. The training will provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves, and general troubleshooting procedures.
- B. Refer to Section 15002 for additional training requirements.
- C. Operation and Maintenance manuals, including as-built wiring diagrams and component lists shall be provided for each training attendee. Refer to Section 23 01 00 for additional requirements.

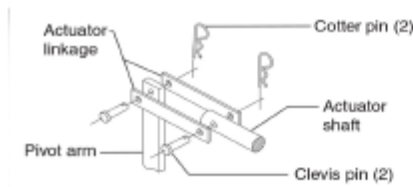


Fig. 1 Linkage connection for normally closed pneumatic valves (normally open valves similar).

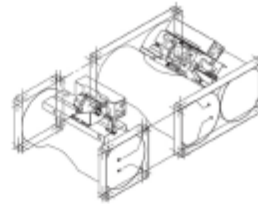


Fig. 3 Points for fastening multiple assemblies.

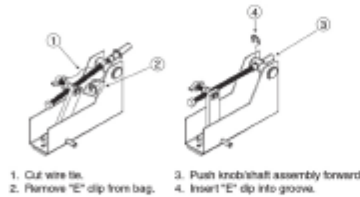
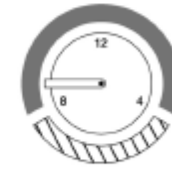


Fig. 2 Constant volume valves.



Acceptable valve positions are 8 to 9 o'clock or 3 to 4 o'clock

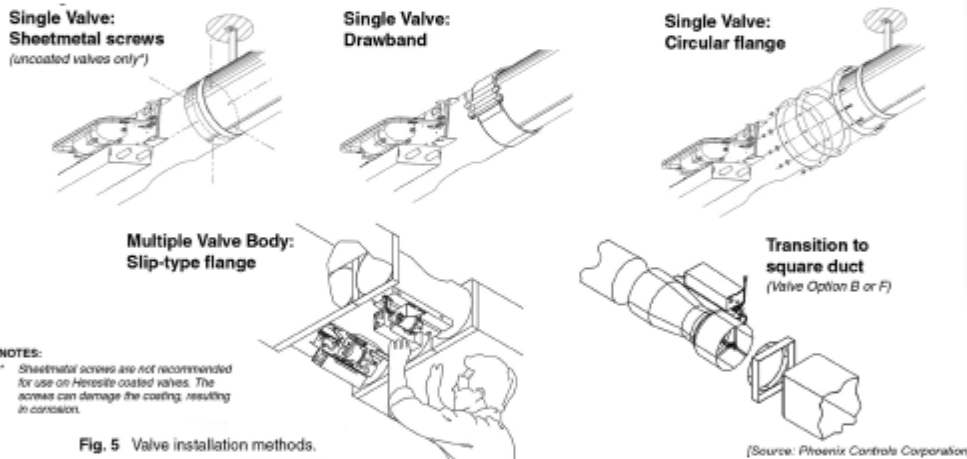


Fig. 5 Valve installation methods.

[Source: Phoenix Controls Corporation]

INSTALLATION

1. Read all instructions completely before installing the valves.
2. Check that tag number on valve label matches HVAC schedule.
3. Verify correct airflow direction and orientation of the valve in the ductwork (e.g., horizontal). NOTE: Valves mounted out of horizontal or vertical position (as determined by a level) will affect valve performance.
4. Allow a minimum of 14 in. of free unobstructed space around the valve for access. In general, the valve may be installed in a 360° rotation. However, single body horizontal hood valves should be installed so that the pivot arm is located between 8 to 9 o'clock or 3 to 4 o'clock.
5. Allow 6.75" of unobstructed space in the duct on the valve's inlet side for the shaft to reach the maximum flow position.
6. Linkage Connection—many valves require field connection of pivot arm (see Figs. 1 and 2).
7. For multiple valves, assemble the valve sets on the floor using duct sealant and fasteners. (See Fig. 3). Slip L style mating piece onto valve flange.
8. Use duct sealant on all valve/duct connections (or flange gaskets for circular flanges).
9. Install a hanger stock to support the ductwork within 12 in. of the valve connection. Install valve into duct after hanger stock is in place. Install the valve by sleeving it into the duct after the hanger stock is in place.
10. Follow the appropriate installation diagram (see Fig. 5). Procure screws, fasteners, duct sealant, hanger stocks, companion flanges, and gaskets if not provided by valves manufacturer.
11. Seal per manufacturer's instructions.
12. Do not install in a location that will require climbing over existing pipes or duct work; do NOT stack one on top of another, and do not located at an excessive height as to become a safety hazard for maintenance personnel. Ensure that there is sufficient clearance that if the valve should ever have to be replaced that it can be without disassembling any other systems, piping, conduit, and or duct work.

FIGURE A. VALVE INSTALLATION

END OF SECTION 23 09 10

SECTION 23 12 00 - HEAT EXCHANGERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide heat exchangers as shown, scheduled, indicated, and as specified.
- B. Types: The types of heat exchangers required for the project include, but are not limited to:
 - 1. Shell and tube heat exchangers.
 - 2. Flat plate heat exchangers.

1.3 QUALITY ASSURANCE:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
 - 1. Shell and Tube Heat Exchangers:
 - a. Bell & Gossett.
 - b. Patterson-Kelly.
 - c. Taco.
 - 2. Flat Plate Heat Exchangers:
 - a. Alfa-Laval.
 - b. Baltimore Aircoil.

1.4 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
 - 1. Cut sheets of the heat exchangers with construction, capacity, ratings, and accessories clearly shown.
 - 2. Include dimensioned drawings of heat exchangers.
 - 3. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver heat exchangers in factory-fabricated water-resistant wrapping.
- B. Handle heat exchangers carefully to avoid damage to material component, enclosure and finish.
- C. Store heat exchangers in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 SHELL AND TUBE HEAT EXCHANGERS:

- A. General: Provide shell-and-tube heat exchangers, complete with steel supporting saddles.
- B. Exchangers: Design water-to-water heat exchangers with number of passes and arranged as indicated on the Drawings. **[Steam to hot water converters shall be piped with steam in shell and a minimum of two water passes.]**
- C. Construction: Construct components of following materials:
 - 1. Components Material
 - Shell Steel
 - Tube sheets [Naval Brass] [Muntz Metal]
 - Tubes [Stainless Steel] [18 BWG inhibited Copper Admiralty metal]

Heads (Removable) [5/8" OD,] [3/4" OD,]
[Cast iron] or [fabricated steel]

- D. Capacity: Provide units with capacities as scheduled on the Drawings. Pressure drops scheduled are maximum. Fouling factor of 0.0005 shall be included. **[Scale factor shall be 0.003.]** Water velocity shall not exceed 4 fps.
- E. **[Steam Connections: Provide steam, condensate, and vent connections to the exchanger shell. Steam inlet connection on shell shall be beyond the tube U-bends to prevent steam impingement on the tubes.]**
- F. ASME Symbol: A manufacturer's data report for pressure vessels, Form No. U-1 as required by the provisions of the ASME Code Rules, shall be furnished to the Engineer for the Owner. This form shall be signed by a qualified inspector holding a National Board commission certifying that construction conforms to the latest ASME Code for Pressure Vessels for 300 psig design pressure and system temperatures as indicated on the Drawings and as detailed on Form No. U-1. The ASME "U" symbol shall be stamped on the heat exchangers.
- G. Mounting Saddles:
- H. Painting: Heat exchangers and accessories shall be primed and finish-painted using the manufacturer's standard paint system.

2.2 FLAT PLATE HEAT EXCHANGERS:

- A. General: Provide flat plate heat exchangers, complete with frames and accessories.
- B. Exchanger Design: Design flat plate heat exchangers with number of plates and plate size required to provide the scheduled capacity. Pressure drops scheduled are maximum. Fouling factor of 0.0005 shall be included. Water velocity shall not exceed 4fps.
- C. Frame: Heat exchanger shall be provided with an epoxy coated steel frame with lifting lugs. Frame plate and bar design shall permit access to any plate in the plate pack without need to remove any other plates. All plate carrying and guide bar guiding system components shall be stainless steel. Carrying and guiding bars shall be designed for 15% future plate expansion capability. The fixed and movable covers shall be of sufficient thickness for the design pressure and code requirements without additional reinforcements of stiffeners.
- D. Connections: Connections 2" and smaller shall be stainless steel NPT type. Connections 2-1/2" and larger shall be studded port design to avoid leaks on the port area.
- E. Compression Bolts: The bolting system shall utilize only four compression bolts for opening and closing the unit. Compression bolts shall not require special tools and shall be equipped with lock washers at the movable cover to allow opening and closing of the unit from the fixed cover. Compression bolts shall be equipped with captive nuts at the fixed cover and threaded nuts at the movable cover. Welding of nuts to the compression bolts will not be acceptable. Compression bolts shall have rolled threads to reduce galling and double width hex nuts to adequately distribute bolt load. Bolts shall be factory lubricated and provided with protective plastic sleeves.
- F. Plates: Plates shall be pressed type 304 stainless steel with adequate heat transfer area to provide the scheduled capacity. Each individual plate shall be pressed from a homogeneous single metal sheet. Each transfer plate shall have herringbone corrugations to optimize heat transfer and provide support of adjacent plates. All plates and gaskets shall be permanently marked to identify quality and material. Plates shall incorporate a built-in aligning system. An aluminum plate pack shroud shall be provided.
- G. Gaskets: Gasket material shall be as scheduled or required for the proposed application. Gaskets shall have relieving grooves to prevent intermixing of fluids. All gaskets shall be one piece and shall fit around both the heat transfer areas and port holes. Non-glued gasketing systems are preferred. If adhesive is necessary, it shall be a two component heat cured epoxy glue which is compatible with the gasket materials and heat exchange fluids.
- H. Inspection and Testing: Plate heat exchangers shall be designed to withstand the full test pressure in one circuit with zero pressure in the alternate circuit. All exchangers shall be hydrostatically tested in accordance with ASME Section VIII, Division 1, Paragraph UG-99.

- I. Factory Insulation: Plate heat exchangers shall be provided with a factory installed insulation package. Insulation shall meet the flame spread and smoke developed requirements specified in Section 230700, "System Insulation".
- J. Drip Tray: Plate heat exchangers shall be provided with a factory installed drip tray.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install in accordance with manufacturer's instructions and ASME Code. Provide a pressure relief valve on closed loop side to prevent excessive buildup of heat or pressure. Relief valve shall be selected to coordinate with the piping system pressure rating.

3.2 TESTING:

- A. General: Test heat exchangers with connected piping systems.

3.3 INSULATION:

- A. Refer to Section 23 07 00, "System Insulation", for non-factory insulated heat exchanger component insulation requirements.

3.4 DRIP TRAY:

- A. Pipe condensate from heat exchanger drip tray to the nearest floor drain..

3.5 IDENTIFICATION:

- A. Refer to Section 23 03 00, "Basic Materials and Methods", for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 12 00

SECTION 23 20 00 - HVAC PIPING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide complete operating HVAC 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:

<u>System</u>	<u>Working Pressure</u>	<u>Operating Temperatures</u>
Chilled Water		
High	300 psig	40°F to 60°F
Medium	300 psig	40°F to 60°F
Low	150 psig	40°F to 60°F
Condenser Water		
High	300 psig	65°F to 100°F
Medium	300 psig	65°F to 100°F
Low	150 psig	65°F to 100°F
Heating Hot Water		
High	300 psig	100°F to 180°F
Medium	300 psig	100°F to 180°F
Low	150 psig	100°F to 180°F
Steam/Steam Relief	[150 psig]	[212°F to 375°F]
Steam Condensate/Condensate Vent	[150°F]	[150°F to 250°F]
Condensate Drainage	--	40°F to 60°F
Temperature Control Air	20 to 200 psig	
Diesel Engine Exhaust	--	900°F to 1400°F
Refrigerant	--	--

* Pressures

- High = Floors [_____] through [_____]
- Medium = Floors [_____] through [_____]
- Low = Floors [_____] through [_____]

- C. Basic Materials and Methods: Refer to Section 23 03 00, "Basic Materials and Methods", for additional HVAC piping system requirements.
- D. Valves and Accessories: Refer to Section 23 20 10, "HVAC Piping Valves and Accessories", for additional HVAC piping system components.
- E. Vibration Isolation: Refer to Section 23 05 48, "Vibration Isolation", for piping system isolation.
- F. Insulation: Refer to Section 23 07 00, "System Insulation", for piping system insulation.

1.3 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.

1.4 SUBMITTALS:

- A. Shop drawing submittals shall include, but not be limited to, the following:
 - 1. Cut sheets marked to clearly indicate all HVAC piping system materials.
 - 2. Piping fabrication drawings for all main piping runs **[including connections to existing piping]**. Fabrication drawings shall include plan views and suitable elevations and shall include all accessories and equipment.
 - 3. Pipe fabrication drawings for all pre-insulated underground piping showing location and sizes of all expansion/contraction loops, thrust block location, anchors and guides. Manufacturer shall provide detailed drawings and calculations for review by the Engineer prior to fabrication and installation of systems.
 - 4. Pipe fabrication drawings and cutsheets for all refrigerant piping showing all specified fittings and accessories, pipe lengths and pipe sizes. Submit line sizing calculations approved by compressor unit manufacturer's application engineering department prior to installation of systems.
 - 5. Additional items as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver components in factory-fabricated water-resistant packaging, as applicable.
- B. Handle components carefully to avoid damage to components, enclosures, and finish.
- C. Store components in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 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 or ASTM A106, ANSI B36.10 black as specified. **[Piping shall be domestically manufactured by one of the manufacturers listed in the latest edition of the American Petroleum Institute (API) approved manufacturers listing.]**
 - 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. Preinsulated Steel Pipe: ASTM A53, ASTM A106, and ANSI B31.1. [Piping shall be domestically manufactured by one of the manufacturers listed in the latest edition of the American Petroleum Institute (API) approved manufacturers listing.]

2.2 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 including bolting and gasketing.
 - 2. Malleable Iron Threaded Fittings: ANSI B16.3, Class 150 or Class 300, black as specified.
 - 3. 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 as specified.
 - 4. Threaded Pipe Plugs: ANSI B16.14.

5. Steel Flanges/Fittings: ANSI B16.5 and B16.9, including bolting, gasketing, and butt weld end connections.
6. Forged Steel Socket-welding and Threaded Fittings: ANSI B16.11, rated to match schedule of connected pipe.
7. Wrought Steel Butt-welding Fittings: ANSI B16.9, except ANSI B16.28 for short radius elbows and returns; rated to match connected pipe.
8. 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).
9. Wrought Copper/Bronze Solder-joint Fittings: ANSI B16.22 suitable for working pressure up to 250 psig.
10. Grooved End Fittings: ASTM A47 or ASTM A536 joined with Victaulic Style 77 or Style 07 couplings and Grade "E" gaskets on steel systems. **[On copper systems, ASTM B-75 Alloy 12200 or sand casting B-S84-87 Alloy CDA844 (81-3-7-9) with Style 606 coupling.]**
11. Flanged Fittings: Comply with ANSI B16.15 for bolt-hole dimensioning, materials, and flange-thickness.
12. 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.
13. Flange Bolt Thread Lubricant: Lubricant shall be an antiseize compound designed for temperatures up to 1000°F and shall be Crane Anti-Seize Thread Compound or approved equal.

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: 1/16" thick for all pipe size 10" and smaller and 1/8" thick for all pipe size 12" and larger. 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 nonasbestos 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 "Clearflow" waterway by Victaulic.
5. Solder: All solder used for sweating of joints shall be 95/5 tin-antimony or tin-silver.
6. Threadsealing Tape: Threadsealing tape used for chilled and hot water applications up to 150 psi shall be stretched or nonstretched teflon tape. Threadsealing tape used for chilled and hot water applications over 150 psi and all steam applications shall be nonstretched 0.003" thick teflon tape and shall be color-coded for identification.

PART 3 - EXECUTION

3.1 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, within 1/16" misalignment tolerance. Coordinate piping locations with other trades to avoid conflict. Give ductwork preference unless directed otherwise by the Engineer.

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 anchors, loops, offsets, sizing joints, and expansion joints, as necessary, to avoid strain resulting from expansion and contraction of piping systems on fixtures and equipment.
 - a. Expansion Loops and Offsets: Provide expansion loops and offsets in piping systems for not less than one inch (1") expansion or contraction per 100' of pipe.
 - b. Mechanical Grooved Couplings: Provide mechanical grooved connections where indicated on the Drawings and Specifications to reduce vibration at equipment connections. Provide expansion joints in piping systems by mechanical grooved connections where specifically indicated on the Drawings.
- 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. Use John Crane, or approved equal, or teflon thread tape applied only to male threads to make-up joints.
- C. Copper Pipe: Cut copper pipe square and ream to remove burrs. Clean fitting socket and pipe ends with sand cloth, No. 00 cleaning pads or wire brush.
- D. Final Connections to Equipment Furnished by Owner or Under Other Divisions of These Specifications: Where Drawings show equipment 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 chilled water, hot water, and condenser water as shown. Provide valves, unions, strainers, check valves, and traps as required for proper operation of systems and equipment. Equipment not shown or noted on the piping drawings shall not be included in the scope of this requirement.
- E. Excavation, Installation and Backfill for Underground Pipe:
 1. Layout: Pipes shall be laid and pipe joints made in presence of the Architect and field measurements, layouts, batter board alignment, grade establishments, and similar locations shall be performed by a Professional Engineer in the employ of the Contractor. The Contractor's engineer shall be on the job during all underground work. A "Bench-Mark" reference for use by the Contractor shall be provided by the Architect.
 2. Pipe Grading: Lay and maintain all pipes at required lines and grades during the course of the Work to comply with the Drawings.
 3. Trench: Excavate the trench to the depth required. Properly brace and dewater 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 the Architect. Refer to Section 220000 for additional requirements.
 4. Excavation: The trench shall be at least 18" wider than the maximum diameter of the pipe 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 local regulations or, in the absence thereof, with the "Manual of Accident Prevention in Construction" of the Associated General Contractors of America, Inc. 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. Refer to Section 23 03 00 for additional requirements.
 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 the Engineer. 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 comply with local codes. In absence of local code requirements, the cushion shall be bank sand or select backfill material approved by the Architect. Any material used shall pass a one inch (1") screen.

- a. Stable, Firm Semi-dry Trench: Piping shall be laid on undisturbed earth, in a constant uniformly sloped trench. Laying space for mechanical joints shall be hand cut to 6" either side of the joint and stabilized sand poured and wet in to even with the natural earth trench bottom. The pressure test of the piping system shall be inspected by the Owner's Representative prior to covering the piping. Failure to notify the Owner's Representative for inspection prior to covering the piping will result in the piping being uncovered and the test being performed again. Where the slope of the trench is found to belly down along the line of piping, before joining, the pipe shall be removed from the trench and the belly converted to uniform slope by adding stabilized bank sand, wet down and slightly mounded to the center of the trench. The section of piping will then be "rolled" into place so with support uniform along its entire length. Where the slope of the trench is found to arch up along the line of piping, before joining, the pipe shall be removed from the trench and the arch converted to uniform slope by cutting the arch out. The section of piping will then be reset into place with support uniform along its entire length.
 - b. Wet Clay - Black Gumbo: Piping shall be laid in a constant, uniformly sloped trench. After shaping, the trench shall receive 3" minimum clean bedding sand, which shall be uniformly distributed on the trench bottom. Laying space for the mechanical joints shall then be hand removed and the piping placed on the setting bed with the weight of the piping distributed evenly on the setting bed over its entire length. The pressure test of the piping system shall be inspected by the Owner's Representative prior to covering the piping. Failure to notify the Owner's Representative for inspection prior to covering the piping will result in the piping being uncovered and the test performed again.
 - c. Rock: Where rock is encountered, the trench shall be excavated to a minimum of 6" below the pipe elevation and then backfilled with bedding sand to provide a uniform layer for pipe support. Backfill shall be as indicated for Wet Clay - Black Gumbo.
 - d. Special Considerations: Where the expansive soil conditions on the site, special precautions shall be taken to prevent pushing and breakage of underground piping. Precautions shall be in accordance with local installation techniques and may include carton forms or special pipe bedding. Installation methods shall comply with preinsulated piping system manufacturer's requirements where applicable.
6. Anchors: Pipes shall have concrete anchors/thrust blocks 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 the Architect. Place backfill material in the trench either by hand or approved mechanical methods. The compaction of backfill material shall be accompanied by tamping with hand tools or approved pneumatic tampers, by using vibratory compactors, by puddling, or by any combination of the three. The method of compaction shall be approved and all compaction shall be done to the satisfaction of the Architect. Backfill completely around pipe, including 18" above the pipe, with suitable bank sand, tamped in 4" layers under, around, and over pipe. Water down backfill as required. The remainder of the backfill for pipes shall be select backfill material tamped at intervals of no more than 12" depths, to attain a 95% Proctor Compaction Density. All materials to be used as select material backfill shall be approved by the Architect. If, in the opinion of the Architect, the excavated material does not meet the requirements of select material, the Contractor shall be required to screen the material prior to its use as select material backfill. Material used in the upper portion of the backfill or subgrade shall not contain stone, rock, or other material larger than 6" in its longest dimension. No wood, vegetable matter, or other material, which in the opinion of the Architect is unsuitable, shall be included in the backfill. The

upper 24" of backfill may be water jetted, if desired. Bring backfill up to finish grade identified on the Architectural Drawings, including additional backfill required to offset settlement during consolidation. When removal of unsuitable, excavated material creates a shortage of backfill material, the Contractor shall, at no change in Contract amount, furnish material as specified in this Section in the amount required to complete the backfill.

8. Existing Surfaces: Restore existing streets, driveways, and sidewalks damaged during the excavation work to acceptable condition, subject to approval by the Architect.
9. Safety: Provide street and sidewalk excavations with approved barricades, warning lights, d cover plates as required by the City. Refer to Section 23 03 00 and Division 1 for additional requirements.

F. Pipe Fabrication Drawings:

1. Pipe fabrication drawings shall be submitted for all piping in the Central Plant, **[Utility Tunnel,]** Mechanical Rooms, Penthouse and for Equipment connections and all other areas requiring coordination with other trades.
2. Pipe fabrication drawings shall be double line drawings to scale on 1/4" scale building floor plans and shall indicate pipe size, fittings, valves, accessories, connections, system type, insulation, support requirements, pipe elevations and other information required for coordination with other trades and fabrication of pipings.
3. Pipe fabrication drawings shall be coordinated with other trades and building construction prior to submittal for approval. Refer to Section 23 01 00 for additional shop drawing requirements.

G. Basic Materials and Methods: Refer to Section 23 03 00 for additional requirements related to HVAC piping.

3.2 CHILLED WATER, CONDENSER WATER AND HEATING HOT WATER PIPING SYSTEMS **[ABOVE GROUND]**:

A. Pipe: Black steel, ASTM A53, Schedule 40, 10" and below, and Standard Weight, 12" and above.

B. 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 125, 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 1/3 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, Class 250, weld neck, welding flanges at valves and all flanged connections.
4. Provide isolation fitting whenever dissimilar materials are used.
5. Option: At the Contractor's option, for piping 4" or larger, a grooved piping connection system with "roll-grooves" or "cut-grooves" may be used. Grooved couplings shall be Victaulic Style 75, Style 77 with Grade "E" gaskets. Rigid couplings shall be used at valves and in other areas where piping system rigidity is required and shall be Victaulic Style 07 Zero-Flex couplings with Grade "E" gaskets. Taps to mains shall be made using Victaulic Style 72 or Style 920 hot dip galvanized outlet couplings or fittings. Mechanical "T" couplings with U-bolts shall not be permitted. Flange connections shall be made using Victaulic Style 741 flanges with Grade "E" gaskets. Fittings for elbows, tees, reducers, etc. shall be Victaulic hot dip galvanized full flow fittings. All grooved piping connection materials shall be utilized with the manufacturer's recommended groove cutting tool. All grooved piping couplings and fittings used in association

with an individual coupling or fitting shall be by the same manufacturer. The use of boltless couplings, reducing couplings and Mechanical "T" fittings with U-bolts is prohibited. All wetted surfaces in the piping system shall be hot dip galvanized and all proposed grooved piping connection materials shall be suitable for domestic water use at the temperatures and pressures at the point of application. Painted couplings may be used where they meet the above requirements. Grooved reducing couplings shall not be installed.

- C. All piping shall be a butt welded system in accordance with ANSI B31.1.0 except with flanges where required for service or equipment connections. All flanged or screwed connections shall be accessible for repair and shall not be permitted in inaccessible locations. Screwed fittings and flanges may be used on pipe sizes up thru 2" IPS. All taps shall be made using factory-manufactured fittings.
- D. Welded fittings shall be factory made wrought steel in accordance with ANSI B16.9 with wall thickness and material identical to pipe being fitted. Flanges shall be ANSI B16.5 forged steel with beveled edge weld type neck. Branch piping taps more than one size smaller than the main shall be made with weld-o-lets and/or thread-o-lets (integrally reinforced branch weld-on fittings) manufactured in accordance with ANSI B16.9. All butt weld fittings shall have wall thickness as specified by ANSI B31.1.0 and ANSI B36.10 standards and they shall be suitable for the working pressure and temperature of the piping that they are installed in. No branch piping tap to the main shall be made by burning a hole in the main, inserting the end of the branch piping and then welding the branch piping to the main.
- E. Cold-springing: Cold-springing of piping will not be permitted.
- F. Pitch: Install chilled, hot, and condenser water piping with an upward pitch in direction of flow and to air vents of not less than one inch (1") in 40'.
- G. Basic Piping Installation: Refer to Section 23 03 00.

3.3 **[CHILLED AND CONDENSER WATER PIPING SYSTEMS UNDERGROUND:]**

- A. **[Piping: Underground chilled water piping shall be Ric-Wil Chil-Gard or an approved equal preinsulated piping composed of integral sealed units of PVC plastic outer jacket, 150 psig PVC plastic carrier pipe, and insulated with polyurethane foam completely filling the annular space between the pipe and jacket. Jacket ends shall be protected with factory applied moisture barrier. Underground condenser water piping shall be Manville DR-25 "Blue Brute" or approved equal PVC bell and spigot type and shall be designed for 100 psig and shall be Class 100 in accordance with AWWA C900 requirements for Polyvinyl Chloride (PVC) pressure pipe.]**
- B. **[Connections: Units and fittings shall be joined with integral bell and spigot joints, including a rubber sealing ring. All pipe shall be suitable for use as a pressure conduit. Provisions shall be made for expansion and contraction at each joint with an elastomeric ring. The bell shall consist of an integral wall section with a solid cross-section elastomeric ring which meets the requirements of ASTM D1869 and ASTM E477. The bell section shall be designed to be as least as strong as the pipe wall. Standard laying lengths shall be 20'. Each length of pipe shall be tested to four times the class pressure of the pipe for a minimum of 5 seconds. The integral bell shall be tested with the pipe.]**
- C. **[All steel piping adjoining this system shall be anchored at or near the point of connection. Connection between PVC and steel pipe shall be made by inserting steel pipe into PVC end or with a flexible expansion coupling as recommended by the manufacturer. The Contractor shall pour concrete thrust blocks, prior to testing pipe, at every change of direction. The block size shall be in accordance with normal water line installation for the existing soil conditions and in accordance with the manufacturers recommendations.]**
- D. **[Expansion and contraction shall be taken up as recommended by pipe manufacturer.]**
- E. **[All required calculations for the sizing and placement of concrete thrust blocks at all changes in direction shall be provided by the preinsulated piping manufacturer. Soil loading information shall be provided by the Structural Engineer. The Mechanical Contractor shall submit thrust block sizing calculations for review by the Engineer prior to installation of below grade pipe. Calculations shall include thrust in pounds, bearing area of thrust block in square feet and direction of thrust. General Contractor shall furnish and install all required concrete formwork and shall pour all concrete for thrust blocks.]**

- F. [Immediately after the system is installed in the trench, a partial backfill shall be made in the middle of each unit, leaving the joints exposed for inspection during the hydrostatic testing. After all thrust blocks are poured, a hydrostatic test as specified hereinbelow shall be performed. After successful hydrostatic testing, backfill trench as specified.]

3.4 [CHILLED AND HEATING HOT WATER PIPING SYSTEMS UNDERGROUND:]

- A. [Piping: Underground chilled and heating hot water piping shall be Ric-Wil Terra-Gard System or an approved equal composed of integral sealed units of PVC plastic outer jacket, black steel standard weight class carrier pipe in accordance with ANSI B36.10. Preinsulated black steel pipe with insulation and "FRP" outer jacket as manufactured by Perma-Pipe shall be considered an equal. Piping 4" and smaller shall be ASTM A120 black steel. Piping 5" and larger shall be black steel ASTM A53 seamless or electric resistance welded (fully normalized after welding). All piping shall be a butt welded system in accordance with ANSI B31.1.0. The piping system shall be insulated with polyurethane foam completely filling the annular space between the pipe and jacket. Jacket ends shall be protected with factory applied moisture barrier.]
- B. [Connections: All elbows, tees, couplings, will be prefabricated and insulated by manufacturer. Insulation and vapor barrier shall be installed over welded areas in accordance with manufacturer's published data and shall be of the same material and thickness as the adjacent straight section.]
- C. [Expansion and contraction shall be taken up as recommended by pipe manufacturer.]
- D. [All required calculations for the sizing and placement of concrete thrust blocks at all changes in direction shall be provided by the preinsulated piping manufacturer. Soil loading information shall be provided by the Structural Engineer. The Mechanical Contractor shall submit thrust block sizing calculations for review by the Engineer prior to installation of below grade pipe. Calculations shall include thrust in pounds, bearing area of thrust block in square feet and direction of thrust. General Contractor shall furnish and install all required concrete formwork and shall pour all concrete for thrust blocks.]
- E. [The Contractor shall pour concrete thrust blocks, prior to testing pipe, at every change of direction. The block size shall be in accordance with normal water line installation for the existing soil conditions and in accordance with the manufacturers recommendations.]
- F. [Immediately after the system is installed in the ditch, a partial backfill shall be made in the middle of each unit, leaving the joints exposed for inspection prior to the hydrostatic test. After all thrust blocks are poured, a hydrostatic test as specified in Section 23 05 93, "Operational Test-Adjust-Balance", shall be performed.]

[OR]

3.5 [CHILLED AND HEATING HOT WATER PIPING SYSTEMS UNDERGROUND:]

- A. [General: Underground chilled and heating hot water piping shall be Perma-Pipe Poly-Therm preinsulated pipe installed in a factory conduit system, or an approved equal and shall be fully compatible with the existing piping system which is being connected to. All straight sections, fittings, anchors and other accessories shall be factory-fabricated to job dimensions and designed to minimize the number of field welds. Each system layout shall be computer analyzed by the piping system manufacturer to determine stress on the carrier pipe and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ANSI B31.1, latest edition. Factory-trained field-supervision shall be provided for critical periods of installation, i.e. unloading, field joint instruction, and testing.]
- B. [Internal Piping: Internal piping shall be Schedule 40 black steel per ASTM A53. All joints shall be butt-welded for sizes 2-1/2" and greater, and socket-welded for 2" and below. Straight sections shall be supplied with 8" of piping exposed at each end for field joint fabrication. End seals, gland seals, and anchors shall be designed and factory-fabricated to prevent the ingress of moisture into the system.]
- C. [Insulation: Carrier pipe insulation shall be spray-applied nominal 2 pounds per cubic foot density, polyurethane foam for straight sections and performed polyurethane foam for all

fittings. To ensure no voids are present, all insulation shall be inspected by one of the following three methods: visually checked prior to application of the protective jacket, infrared inspection of the entire length, or x-ray inspection of entire length. The insulation shall be applied to a minimum thickness of [3"] [_____].]

- D. [Protective Jacket: All straight sections of the insulated piping system shall be jacketed in a 180 mil filament-wound, polyester resin/fiberglass reinforcement composite directly applied on the insulating foam to the nominal Thickness specified below. Thermoplastic casing material, e.g. PVC or PE shall not be allowed. All fittings of the insulated piping system shall be prefabricated to minimize field joints and jacketed in a chipped spray-up, polyester resin/fiberglass reinforcement composite, directly applied onto the insulating foam to a thickness related to the filament wound jacket thickness.]**
- E. [Field Joints: After the internal pipe has been hydrostatically hammer-tested to 150 psig or 1-1/2 times the operating pressure, whichever is greater. Insulation shall then be poured in place into the field weld area. All field-applied insulations shall be placed only in straight sections. Field-insulation of fittings shall be made of clear adhesive backed polyester film. The installer shall seal the field-joint with wrappings of glass reinforcement fully saturated with a catalyzed resin identical in properties to the factory-applied resin. The joint area shall be backfilled only after the jacket has hardened, and has been visually inspected. All insulation and coating materials for making the field-joint shall be furnished by the piping system manufacturer.]**
- F. [Backfill: A 4" layer of sand or fine gravel shall be placed and tamped in the trench to provide a uniform bedding for the pipe. The entire trench width shall be evenly backfilled with a similar material as the bedding is 6" compacted layers to a minimum height of 6" to 12" above the top of the insulated piping system. The remaining trench shall be evenly and continuously backfilled in uniform layers with suitable excavated soil.]**
- G. [All piping shall be clean when it is installed. Before installation it shall be checked, upended, swabbed, if necessary, and all rust or dirt from storage or from laying on the ground shall be removed. The Contractor is cautioned to exercise rigid control of the interior cleanliness of the pipe as it will be impossible to flush clean after assembly.]**
- H. [Thrust Blocks: Thrust blocks shall be provided at all changes in direction of underground water piping, as shown on the Drawings or recommended by the manufacturer.]**

3.6 STEAM PIPING SYSTEMS:

- A. Pipe: Black steel, ASTM A53, Schedule 40.**
- B. Fittings: Service pressure up to 300 psig:
 - 1. Fittings, 2" in diameter and smaller, threaded, Class 250 rated, 300 psig, black, banded, malleable iron.
 - 2. Fittings, 2-1/2" in diameter and larger, factory-fabricated, Class 250, full flow weld-type.
 - 3. Flanges, Class 250, forged steel weld neck.**
- C. All piping shall be a butt welded system in accordance with ANSI B31.1.0 with flanges where required for service or equipment connections. All flanged or screwed connections shall be accessible for repair and shall not be permitted in inaccessible locations. Screwed fittings and flanges may be used on pipe sizes up through 2" IPS at pressure up to 100 psig. At pressures above 100 psig, socket welded fitting shall be used for pipe sizes up to 2". All taps shall be made using factory-manufactured fittings.**
- D. Welded fittings shall be factory made wrought steel in accordance with ANSI B16.9 with wall thickness and material identical to pipe being fitted. Flanges shall be ANSI B16.5 forged steel with beveled edge weld type neck. Branch piping taps one half the main size or smaller on piping at pressures up to 100 psig may be made with weld-o-lets and/or thread-o-lets (integrally reinforced branch weld-on fittings) manufactured in accordance with ANSI B16.9. All taps for branches at pressures above 100 psig shall be made using fittings welded in-line in the main being tapped. All butt weld fittings shall have wall thickness as specified by ANSI B31.1.0 and ANSI B36.10 standards and they shall be suitable for the working pressure and temperature of the piping that they are installed in. No branch piping tap to the main shall be made by burning a hole in the main, inserting the end of the branch piping and then**

welding the branch piping to the main. Piping shall be installed in such a manner as to not obstruct the removal of filters, lubrication or general servicing of connected equipment. The routing of piping shall be placed so as to conserve as much space as possible in equipment rooms. Flat bushings, bull head tee connections and other piping connections which cause excessive pressure drop are not permitted. Reductions in line size for control valves shall not be made more than two pipe diameters away from the connections to the valve.

- E. All steam apparatus and risers shall have steam traps sized for flow of piping. All steam piping take-offs shall be made off the top of the steam supply main or header. All steam condensate trap connections shall be made off the bottom of the steam main or header. All steam equipment shall have a minimum 3/4" diameter by 12" long "dirt" leg and a properly sized steam trap in the steam trap in the steam line serving the equipment.
 - F. Cold-springing: Cold-springing of piping will not be permitted, unless scheduled or shown otherwise on the Drawings.
 - G. Pitch: Install steam piping with a downward pitch of not less than one inch (1") in 40' in the direction of flow, toward traps and as shown on the Drawings.
 - H. Traps: Refer to Section 23 20 10.
 - I. Basic Piping Installation: Prefer to Section 23 03 00.
- 3.7 PUMPED CONDENSATE RETURN PIPING SYSTEMS:
- A. Pipe: Black steel, ASTM A53 or A120, Schedule 80.
 - B. Fittings: Service pressure up to 150 psig:
 - 1. Fittings, 2" in diameter and smaller, threaded, Class 150 rated, black, banded, malleable iron.
 - 2. Fittings, 2-1/2" in diameter and larger, factory-fabricated, Class 150, full flow weld-type.
 - 3. Flanges, Class 150, forged steel weld neck.
 - C. All piping shall be a butt welded system in accordance with ANSI B31.1.0 with flanges where required for service or equipment connections. All flanged or screwed connections shall be accessible for repair and shall not be permitted in inaccessible locations. Screwed fittings and flanges may be used on pipe sizes up through 2" IPS at pressure up to 100 psig. At pressures above 100 psig, socket welded fitting shall be used for pipe sizes up to 2". All taps shall be made using factory-manufactured fittings.
 - D. Welded fittings shall be factory made wrought steel in accordance with ANSI B16.9 with wall thickness and material identical to pipe being fitted. Flanges shall be ANSI B16.5 forged steel with beveled edge weld type neck. Branch piping taps one half the main size or smaller on piping at pressures up to 100 psig may be made with weld-o-lets and/or thread-o-lets (integrally reinforced branch weld-on fittings) manufactured in accordance with ANSI B16.9. All taps for branches at pressures above 100 psig shall be made using fittings welded in-line in the main being tapped. All butt weld fittings shall have wall thickness as specified by ANSI B31.1.0 and ANSI B36.10 standards and they shall be suitable for the working pressure and temperature of the piping that they are installed in. No branch piping tap to the main shall be made by burning a hole in the main, inserting the end of the branch piping and then welding the branch piping to the main.
 - E. All steam apparatus and risers shall have steam traps sized for flow of piping. All steam piping take-offs shall be made off the top of the steam supply main or header. All steam condensate trap connections shall be made off the bottom of the steam main or header. All steam equipment shall have a minimum 3/4" diameter by 12" long "dirt" leg and a properly sized steam trap in the steam trap in the steam line serving the equipment.
 - F. Cold-springing: Cold-springing of piping will not be permitted, unless scheduled or shown otherwise on the Drawings.
 - G. Pitch: Install condensate return piping with an upward pitch in direction of flow of not less than one inch (1") in 40'.
 - H. Basic Piping Installation: Refer to Section 23 03 00.

[SELECT ONE OF THE FOLLOWING]

3.8 **[UNDERGROUND STEAM AND STEAM CONDENSATE PIPING SYSTEMS:]**

- A. **[Piping:** Underground steam and steam condensate piping shall be Ric-Wil Imperial Smoothwall Epoxy Coated Conduit System or equal system consisting of an epoxy-coated black steel outer conduit, Ric-Wil fiberglass insulation, internal pipe support guides and steam or steam condensate piping as specified hereinabove.]
- B. **[Fittings:** Premanufactured matching fittings shall be provided as required. All pipe joints shall be butt welded. Joint insulation and conduit cover shall be as recommended by the manufacturer. Provide leakplates and end and gland seals at conduit entry to building. Prefabricated plate anchors shall be provided if shown on the Drawings.]
- C. **[Expansion and contraction shall be taken up as recommended by pipe manufacturer.]**
- D. **[All required calculations for the sizing and placement of concrete thrust blocks at all changes in direction shall be provided by the preinsulated piping manufacturer. Soil loading information shall be provided by the Structural Engineer. The Mechanical Contractor shall submit thrust block sizing calculations for review by the Engineer prior to installation of below grade pipe. Calculations shall include thrust in pounds, bearing area of thrust block in square feet and direction of thrust. General Contractor shall furnish and install all required concrete formwork and shall pour all concrete for thrust blocks.]**
- E. **[Provide thrust block pipe anchors and pipe expansion loops as shown on the Drawings.]**
- F. **[The completed piping system shall be pressure tested as specified hereinbelow before joint insulation and trench cover-up. After pressure testing, backfill trench as specified.]**

[OR]

3.9 **[UNDERGROUND STEAM AND CONDENSATE PIPING SYSTEMS:]**

- A. **[General:** Underground steam and condensate piping shall be the drainable and dryable Perma-Pipe RezCon-A type or an approved equal and shall be fully compatible with the existing piping system which is being connected to. The system supplier shall have fabricated systems of the composition defined herein for at least 3 years. All straight sections, fittings, anchors and other accessories shall be factory-prefabricated to job dimensions and designed to minimize the number of field welds. Each system layout shall be computer analyzed by the piping system manufacturer to determine stresses on the carrier pipe and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ANSI B31.1, latest edition. Factory-trained field supervision shall be provided for the critical periods of installation, i.e., unloading, field joint instruction and testing.]
- B. **[External Piping:** Piping shall be Schedule 60 carbon steel for steam piping and Schedule 80 carbon steel for condensate piping. All joints shall be butt-welded for sizes 2-1/2" and greater, and socket welded for 2" and below. Straight sections shall be supplied with 6" of piping exposed at each end for field joint fabrication. Gland seals and anchors shall be designed and factory-prefabricated to prevent the ingress of moisture into the system. All sub-assemblies shall be designed to allow for complete draining and drying of the conduit system.]
- C. **[Insulation:** Carrier pipe insulation shall be calcium silicate. Split insulation shall be held in place by stainless steel bands installed on not less than 18" centers. The insulation shall have passed the most recent boiling test and other requirements specified in the Federal Agency Guidelines Specifications FCGS 15705. The insulation shall be applied to a thickness of inches.]
- D. **[Outer Conduit:** Conduit casing shall be a 180 mil airtight, pressure testable, multi-layered composite fiberglass reinforced thermosetting resin pipe comprised of a two-part corrosion barrier not less than 45 mils thick and a filament wound structural wall. The glass to resin ratio for the inner surface, corrosion barrier and structural wall shall be not greater than 20:80, 30:70 and 70:30, respectively. The outer layer shall contain 0.2 to 0.3% by weight of ultraviolet inhibitors for protection during outdoor storage.]
- E. **[Pipe Supports:** All pipes within the outer casing shall be supported at not more than 10' intervals. These supports shall be designed to allow for continuous airflow and drainage of the conduit in place. The straight supports shall be designed to occupy not more than 10% of

the annular air space. Supports shall be of the type where insulation thermally isolates the carrier pipe from the outer conduit. The surface of the insulation shall be protected at the support by a sleeve not less than 12" long, fitter with traverse, and, where required, rotational arresters.]

- F. **[Expansion Loops, Ells and Tees:** Prefabricated ells, loops and tees shall be furnished and installed where shown on Drawings or recommended by the piping system manufacturer and shall consist of pipe, insulation, and conduit conforming to the same specification as hereinbefore specified for straight runs. Expansion loops shall be of proper design in accordance with stress limits indicated by ASME Code for Pressure Piping, District Heating Section. Loop piping shall be installed in conduit suitably sized to handle indicated pipe movement. All inner pipe loops and expansion bends shall be cold sprung 50% in the field by the Contractor.]
- G. **[Anchors:** Prefabricated plate anchors shall be furnished and installed where shown on Drawings or as recommended by the manufacturer and shall consist of a steel plate welded to pipe and conduit. The steel plate shall be 3/8" thick for 6-5/8" to 10-3/4" conduit, 1/2" thick for 12" to 22" conduit and 3/4" thick for conduit over 22". A concrete block shall be cast over the plate and conduit shall be large enough for firm anchorage into undisturbed trench sidewalls and/or bottom. The concrete block to be at least 30" in length and extend a minimum of 9" beyond the top and bottom of anchor plate.]
- H. **[Conduit Air Test:** All field joints in conduit closures shall be tested for leaks before backfill. During test all field joints shall be checked with soap suds and resealed if necessary until air tight at 15 pounds pressure. The Contractor shall furnish all necessary equipment and labor to perform the air test, including air compressor, gauges, conduit caps, temporary pipe and connections, etc., and complete the test to the satisfaction of the Architect and/or Engineer.]
- I. **[Manufacturer's Field Service Instructor:** Who is technically qualified to determine whether or not the installation is being made in accordance with the manufacturer's recommendations shall be present during critical periods of installation and test of the system. On completion of the installation, the Contractor shall deliver to the Owner a certificate from the manufacturer stating that the installation has been made in accordance with the manufacturer's recommendations.]
- J. **[Installation:** The installing contractor shall handle the system in accordance with the directions furnished by the manufacturer and as approved by the Architect and Engineer. The casing shall be air-tested at 8 psig and the service piping shall be hydrostatically hammer tested to 150 psig or 1-1/2 times the operating temperature, or as specified in the contract documents. The test pressure shall be held for not less than 24 hours.]
- K. **[Backfill:** A 4" layer of sand or fine gravel shall be placed and tamped in the trench to provide a uniform bedding for the conduit. The entire trench shall be evenly backfilled with a similar material as the bedding in 6" compacted layers to a minimum height of 6" above the top of the insulated piping system. Bedding and backfill materials shall be as recommended by the manufacturer.]
- L. **[Thrust Blocks:** Provided at all changes in direction of underground steam and condensate piping, as shown on the Drawings. Pipe expansion loops and anchors shall be provided in underground steam and condensate piping as recommended by the manufacturer. All required calculations for the sizing and placement of concrete thrust blocks at all changes in direction shall be provided by the preinsulated piping manufacturer. Soil loading information shall be provided by the Structural Engineer for the Mechanical Contractor to forward to the manufacturer. The Mechanical Contractor shall submit thrust block sizing calculations for review by the Engineer prior to installation of below grade pipe. Calculations shall include thrust in pounds, bearing area of thrust block in square feet and direction of thrust. Mechanical Contractor shall furnish and install all required concrete formwork and shall pour all concrete for thrust blocks.]

3.10 CONDENSATE DRAINAGE:

- A. **[General:** Drain piping shall be provided from each air handling unit, fan coil unit, water chilling unit, heat exchanger, pump base drain, vessel overflow, auxiliary drain pan, piping system drain, and

elsewhere where drains are required and shall extend to the nearest floor drain, hub drain or condensate drainage system. Drains shall be sized as indicated but not less than the drain connection size. Air handling unit and fan coil unit drains shall have deep seal traps at each blow-through or draw-through unit to maintain water seal. Provide cleanouts on each change of direction on deep seal traps.

- B. Drain piping shall be fabricated of Schedule 40 galvanized steel pipe and threaded fittings or Type "L" hard drawn copper tubing and wrought copper solder type fittings.

C. [Drain piping exposed on the roof shall be painted to match the roof color.]

3.11 COMPRESSED AIR PIPING SYSTEM (TEMPERATURE CONTROL REQUIREMENTS):

- A. Compressed Air Piping: Compressed air piping, 2-1/2" trade size and smaller, for operation at pressures of 150 psig and less shall be **[ASTM A53, Schedule 40, black steel joined by Class 150 pound, banded, black, malleable iron threaded fittings] [ASTM B88 copper tubing Type "L" with cast bronze solder joint fittings, ANSI B16.18, or wrought copper bronze solder joint fittings, ANSI B16.22, except brass compression-type fittings at connections to equipment.]**

3.12 REFRIGERANT PIPING:

- A. General: Refrigerant piping shall be fabricated of Type L hard drawn "ACR" tubing that has been cleaned and capped for refrigeration service. Fittings shall be wrought copper and shall be installed with silver solder joints. The end of all pipe and the inside of all fittings shall be carefully cleaned before joining. No acid shall be used in cleaning or as a flux in soldering joints. Bleed nitrogen through all piping while soldering.
- B. Furnish, size, install and insulate refrigerant pipe for the system as shown. Submit Shop Drawings of piping system showing all traps, pipe sizes, and accessories. Drawings to be marked "Approved", and signed by a representative of the Application Engineering Department of the condensing unit manufacturer. Pipe sizes to be as recommended by unit manufacturer. Submit line sizing calculations for review by Engineer.
- C. Provide replaceable core type liquid line filter dryer sized for system capacity at 2 psig pressure drop per ARI Standard 710, sight glass-moisture indicator, thermal expansion valve with adjustable superheat, refrigerant shutoff, relief and solenoid valves recommended by the equipment manufacturer.
- D. Install and insulate all refrigerant piping per unit manufacturers latest published recommendations. Slope all lines to facilitate oil return to compressor. Provide suction line traps per manufacturers recommendations. Refrigerant piping shall be installed as shown except that modification shall be made as recommended by the compressor manufacturer. Such modifications shall be made at no cost to the Owner.
- E. Test and dehydrate all refrigerant piping as specified hereinbelow.
- F. After dehydration, introduce the manufacturers recommended type and quantity of refrigerant into system through a filter/dryer.

3.13 DIESEL ENGINE EXHAUST PIPING:

- A. Pipe: Black steel, ASTM A53, Schedule 40.
- B. Fittings: Factory-fabricated Class 150, weld-type.
- C. All connections shall be welded and all weld type fittings shall be smooth radius type as recommended by the diesel engine manufacturer (minimum center line radius shall be 1.5 times the pipe diameter. Provide weld neck flanges where required for connection to diesel engine, muffler, and flexible connection supplied with the emergency generator by Division 16.
- D. Mechanical Contractor shall install and insulate complete diesel exhaust system. All required accessories; muffler, flex connector, roof or wall thimble and weatherproof discharge flapper shall be provided with the emergency generators by the Division 16 Contractor **[and with the fire pump(s) by the Fire Protection Contractor]**.
- E. Size of the diesel exhaust piping shall be coordinated with the engine furnished and the actual field routing and installation shall be in accordance with the detail shown on the mechanical drawings. This coordination shall be performed prior to any fabrication or installation.

3.14 CLEANING, FLUSHING, TESTING AND INSPECTING:

- A. Cleaning: Clean exterior surfaces of installed piping systems and prepare surface for application of any required coatings.
- B. 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 the Engineer and local inspectors and results presented to the Engineer for acceptance and approval prior to concealing piping from view. Provide all necessary equipment for testing, including pumps and gauges. Refer to Section 220000 for additional requirements.
 2. Steam and Water Systems: Test all pressurized HVAC steam and water piping systems hydrostatically to a pressure of 150 psig or 1-1/2 times working pressure, whichever is greater, for a period of 24 hours. Repair all leaks, replacing materials as necessary, and repeat tests until systems are proven tight. Flush water piping systems with clean water and steam and condensate systems with steam following successful testing. Refer to Section 230300 for additional pipe flushing and cleaning requirements.
 3. Condensate Drainage System: Test condensate drainage piping by plugging all openings and filling system to height of 10' above the level of the pipe being tested, for a minimum of 4 hours. Inspect all joints for leaks, repair all leaks found, and retest until piping is demonstrated to be free from leaks as evidenced by no perceptible lowering of the water level after 4 hours.
 4. Compressed Air Piping Systems: Test compressed air piping with compressed air or nitrogen to a pressure at 150% of the expected maximum service pressure, but not less than 150 psig, for a period of 24 hours. Repair all leaks, replacing materials as necessary, and repeat test until systems are proven tight.
 5. Refrigerant Piping System: After completion of the refrigerant piping system and before charging, test the system with dry carbon dioxide at 250 psig for 24 hours. Test joints under pressure with soap solution. During the test, isolate expansion valves and other auxiliary devices to prevent damage due to high pressure.
 - a. After the initial pressure test has been completed and the system proved tight, introduce a mixture of refrigerant and dry carbon dioxide into the system at 150 psig and test all devices and fittings for leaks using a halide torch.
 - b. Following the satisfactory completion of all tests, evacuate the system by means of a vacuum pump connected to the liquid line. After 20" of vacuum is obtained, close the suction and discharge valves at the compressor and continue evacuation for 24 hours. Vacuum shall be measured with a mercury column vacuum gauge.
- C. Inspecting: Visually inspect each run of each system for completion of joints, adequate hangers, supports, and inclusion of accessories and appurtenances.
- D. Chemical Treating: Refer to Section 23 50 00, "Water Treatment Systems", for flushing and cleaning systems.

3.15 IDENTIFICATION:

- A. Refer to Section 23 03 00 for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 20 00

SECTION 23 20 10 - HVAC PIPING VALVES AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide HVAC piping valves and accessories as specified, and indicated.
- B. Types: The types of HVAC piping valves and accessories required for the project include, but are not limited to:
1. Valves.
 2. Strainers.
 3. Unions.
 4. Flanges.
 5. Gaskets.
 6. Flexible connections.
 7. Flexible hose.
 8. Hose balancing kits.
 9. Compression/Expansion tanks.
 10. Air elimination.
 11. Air vents.
 12. Steam specialties.
 13. Pipe expansion joints.
 14. Gauges and thermometers.
 15. Btu metering.
 16. Flow venturis.
 17. Drain pans.

1.3 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. Jenkins Bros. Valves.
 - c. Lunkenheimer.
 - d. Nibco.
 - e. Red and White.
 - f. Stockham Valves and Fittings.
 - g. Walworth Company.
 - h. KITZ
 2. Ball Valves:
 - a. Apollo.
 - b. Crane.
 - c. Jenkins Bros. Valves.
 - d. Nibco.
 - e. Red & White.

- f. Stockham Valves and Fittings.
- g. KITZ
- h. Milwaukee

3. Butterfly Valves:

- a. Centerline.
- b. Demco.
- c. Dezurik.
- d. Nibco.
- e. Red & White.
- f. Stockham.
- g. KITZ
- h. Milwaukee

4. Check Valves:

- a. Crane Company.
- b. Jenkins Bros. Valves.
- c. Lunkenheimer.
- d. Mission.
- e. Muesco, Inc.
- f. Nibco.
- g. Red and White.
- h. Stockham Valves and Fittings, Inc.
- i. Walworth Company.
- j. Williams-Hager, Clow Pipeline Products, Valve Division.
- k. KITZ
- l. Milwaukee

5. Strainers:

- a. Crane.
- b. Keckley.
- c. Muessco.
- d. Zurn.

1.4 SUBMITTALS:

A. Shop Drawing submittals shall include, but not be limited to, the following:

- 1. Cut sheets on all valves, strainers, unions, flanges, gaskets, flexible hose, hose balancing kits, compression/expansion tanks, air elimination, air vents, steam specialties, gauges and thermometers, Btu metering, and flow venturis clearly showing all ratings, capacities and features.
- 2. Valve samples, when requested.
- 3. Additional information as required in Section 23 01 00.

1.5 DELIVERY, STORAGE AND HANDLING:

- A. Store HVAC piping valves and accessories in their factory-furnished coverings, and in a clean, dry indoor space which provided protection against the weather.

PART 2 - PRODUCTS

2.1 VALVES:

- A. General: All valves shall be similar to numbers listed. All similar type and size valves shall be products of one manufacturer
- B. Applications: Valve application shall be as follows:

<u>Service</u>	<u>Application</u>	<u>Type</u>
Chilled Water, Heating	Shutoff/Balancing	Ball
Hot Water, Condenser Water and Glycol	Shutoff/Balancing Check	Butterfly Silent Check
Steam and Steam Condensate	Shutoff Throttling Check	Gate Globe/Needle Swing Check

[VERIFY REQUIREMENTS]

- C. Pressure Ratings:

<u>System</u>	<u>Working Pressure</u>	<u>Operating Temperatures</u>
Chilled Water[/Glycol]		
High	300 psig	40°F to 60°F
Medium	300 psig	40°F to 60°F
Low	150 psig	40°F to 60°F
Condenser Water		
High	300 psig	65°F to 100°F
Medium	300 psig	65°F to 100°F
Low	150 psig	65°F to 100°F
Heating Hot Water		
High	300 psig	100°F to 180°F
Medium	300 psig	100°F to 180°F
Low	150 psig	100°F to 180°F
Steam/Steam Relief	[150 psig]	[212°F to 375°F]
Steam Condensate/Condensate Vent	[150 psig]	[150°F to 250°F]
Temperature Control Air	20 to 200 psig	

* Pressures
 High = Floors [] through []
 Medium = Floors [] through []
 Low = Floors [] through []

- D. Insulated Piping: Stems on all valves installed in insulated piping shall be extended to allow adequate clearance between the operator and the insulation specified for the piping system when the valve is installed.
- E. Chain Operators: Chain operators shall be provided for all valves installed over 8' above finished floor in the central plant, fan rooms, mechanical rooms, and other areas where valves are exposed.
- F. Flanges: Valve flanges and companion flanges for all valve applications shall be compatible with the valve rating and the system pressure at the point of application. Flanges shall conform to ANSI B16.1 and ANSI B16.10.

G. General Requirements:

1. All valves shall be of threaded or flanged type. No solder connected valves shall be used on this project. All bronze and iron body gate and globe valves shall be of one manufacture for each project. Manufacturers of other types may not be mixed on the same project; i.e., all butterfly valves shall be of the same manufacture, all ball valves shall be of the same manufacture, etc.
2. All valves at system points where the System Working Pressure (SWP) at the point of application, including appropriate pump shutoff head, does not exceed 150 psi, may use Class 150 valves.
3. All bronze gate valves for pressures up to 150 psi shall be ASTM B62 composition bronze. Bronze valves for pressures above 150 psi shall be ASTM B61 steam bronze. All bronze valves shall be union or screw over bonnet, rising stem type with ASTM B-99 alloy 651 or ASTM B371 alloy 694 or equal stem material
4. All bronze ball valves for pressures up to 300 psi shall be ASTM B62 composition bronze or ASTM B584 alloy 844.
5. All iron body valves shall have the pressure containing parts constructed of ASTM A126 Class B cast iron. Stem material shall meet ASTM 584 alloy 876 or ASTM 371 Alloy 694 silicon bronze, B-16 Alloy or its equivalent. All iron body gates and globes shall be bolted bonnet with OS&Y (outside screw and yoke) and rising stem design.
6. All gate valves, globe valves, angle valves and shutoff valves of every character shall have malleable iron handwheels, except iron body valves 2-1/2" and larger which may have either malleable iron or ASTM A126 Class B, gray iron handwheels.
7. Packing for all valves shall be selected for the pressure-temperature service of the valve. It is incumbent upon the manufacturer to select the best quality, standard packing for the intended valve service. At the end of one year period spot checks will be made, and should the packing show signs of hardening or causing stem corrosion then all valves supplied by the manufacturer shall be repacked at no expense to the Owner with a packing material selected by the Owner.
8. Valves located with stem in horizontal position shall be drilled and tapped in accordance with MSS-SP-45 at Boss G to accommodate a drain valve.

H. HVAC Valves For Service at or Less Than 150 PSIG:

1. Ball Valves:
 - a. Ball valves shall be two piece with a full line size (full port) **[chromium plated brass] [316 stainless steel] balls [and stems] [, brass stems]**, and reinforced seats and stuffing box rings. All ball valves shall be designed to permit repacking while valve is in line. Valves shall be furnished with blowoutproof stems. Valves used for balancing shall be provided with balancing stops.
 - b. Ball valves 2" and smaller shall be threaded body bronze or brass valves of a **[standard] [full]** port design. Valves shall be rated for 300 psi WOG and shall conform to Federal Specification WW-V-35B and shall be:
 - 1) Apollo No. 70-100 Series [Standard Port].
 - 2) Crane No. 9032 Series **[Standard Port]**.
 - 3) Nibco No. T-585 Series **[Full Port]**.
 - 4) Red and White No. 5044F Series **[Full Port]**.
 - 5) Stockham No. S-216-BR-R-T **[Standard Port]**.
 - 6) KITZ No. 68 Series **[Full Port]**
 - 7) Milwaukee 400S

- c. HVAC diversion valves 2" and smaller shall be three-way diversion type ball valves, bronze body, 300 psig nonshock WOG at 200°F, Apollo 70-600 Series, Red and White No. 5045 or equal.
2. Butterfly Valves:
 - a. All butterfly valves shall be full tapped and threaded lug type, manufacturer certified for bubbletight, dead end shut off from either direction at design working pressure and temperature without need for down stream flange. Valves 2-1/2" through 5" in size shall have lever type operators with memory stops. Valves 6" and larger and all valves requiring chain operators, shall have enclosed, self-locking wheel-operated worm gear type, waterproof, factory-lubricated operators. Gear segment shall be manganese bronze or ductile iron with a steel or ductile iron worm and oil impregnated bronze bushings or worm shaft. Operators shall have built-in adjustable mechanical stops and position indicators. Valves used for balancing shall be certified suitable for continuous throttling service.
 - b. Valves 2-1/2" and larger shall be 200 psig nonshock WOG at 200°F, ANSI Class 150 with ductile iron lug body, EPDM (EPT) seat, silicon or aluminum bronze disc, 316 or 416 stainless steel upper and lower stems (stems shall be positively connected to the valve disc) and EPDM (EPT) stem seals or shall have single piece disc core/drive stem of EPDM encapsulated ductile iron. Valves shall be:
 - 1) Centerline No. LT Series.
 - 2) Demco No. NE Series 250 psi lug body.
 - 3) Dezurik No. 660, L, RS82, 3, *.
 - 4) Jenkins No. 232EL/EG.
 - 5) Nibco No. LD 2000.
 - 6) Nibco No. GD 3765.
 - 7) Red and White No. [918-B-E-M-*] [938-BN5L/G-*].
 - 8) Stockham No. LD7*2B52E.
 - 9) Victaulic Style VIC-300.
 - 10) KITZ No. 6123E
 - 11) Milwaukee ML233E Lever Milwaukee
 - 12) Milwaukee ML333E Gear
3. Gate Valves:
 - a. Valves 2" and smaller shall be 150 psi SWP, 300 psi WOG rated, all bronze gate valves with solid wedge, union bonnet, inside screw, traveling stem and threaded connections. Valves shall conform to MSS SP-80 and shall be:
 - 1) Crane No. 431 UB.
 - 2) Jenkins No. 47-U.
 - 3) Lunkenheimer No. 3151.
 - 4) Nibco No. T-134.
 - 5) Red and White No. 298.
 - 6) Stockham No. B-120.

- 7) Walworth No. 11.
 - 8) KITZ No. 42T
 - 9) Milwaukee 1151
- b. Valves 2-1/2" and larger shall be flanged bronze mounted Class 125 iron body, outside screw and yoke gate valves with bolted bonnets and solid wedges. Valves 4" and larger for steam service shall be provided with warm-up bypass valves. Valves shall be rated for 125 psi SWP and shall conform to MSS SP-70 and shall be:
- 1) Crane No. 465-1/2.
 - 2) Jenkins No. 651-C.
 - 3) Lunkenheimer No. 1430.
 - 4) Nibco No. F-617-0.
 - 5) Red and White No. 421.
 - 6) Stockham No. G-623.
 - 7) Walworth No. 8726-F.
 - 8) KITZ No. 72
 - 9) Milwaukee 2885A
- c. Valves 2-1/2" and larger shall be flanged bronze mounted Class 250 iron body, outside screw and yoke gate valves with bolted bonnets and solid wedges. Valves 4" and larger for steam service shall be provided with warm-up bypass valves. Valves shall be rated for 250 psi SWP and shall conform to MSS SP-70 and shall be:
- 1) Crane No. 7-1/2E.
 - 2) Jenkins No. 204.
 - 3) Lunkenheimer No. 1436.
 - 4) Nibco No. F-667-0.
 - 5) Stockham No. F-667.
 - 6) Walworth No. 8786-F
 - 7) Milwaukee 2894a
4. Needle Valves: Valves one inch (1") and smaller shall be Mueller Steam Company Type 21 female-female globe type brass needle valves rated for 500 psi at 150°F and 100 psi saturated steam.
5. Globe Valves:
- a. Valves 2" and smaller shall be 150 psi SWP, 300 psi WOG rated, all bronze globe valves with renewable disc, screw over or union bonnet and threaded connections. Valves shall conform to MSS SP-80 and shall be:
- 1) Crane No. 7TF.
 - 2) Jenkins No. 106-A.
 - 3) Lunkenheimer No. 123.
 - 4) Nibco No. T-235-Y.
 - 5) Red and White No. 221.

- 6) Stockham No. B-22-T.
- 7) Walworth No. 3095.
- 8) KITZ No. 09
- 9) Milwaukee 590T

b. Valves 2" and smaller for bypass or throttling service shall be 150 psi SWP, 300 psi WOG rated, all bronze globe valves stainless steel plug disc and seat ring, union bonnet and threaded connections. Valves shall conform to MSS SP-70 and shall be:

- 1) Crane No. 14-1/2-P.
- 2) Jenkins No. 546-P.
- 3) Lunkenheimer No. LQ-600-150.
- 4) Nibco No. T-276-AP.
- 5) Stockham No. B-29.
- 6) Walworth No. 3237-P.
- 7) KITZ No. 17S
- 8) Milwaukee 593A

c. Angle and Y-pattern globe valves corresponding to the standard globe valve models specified above may be used where more suited to the installation location.

d. Valves 2-1/2" and larger shall be flanged bronze mounted Class 125 iron body, outside screw and yoke globe valves with bolted bonnets and renewable seat and disc. Valves shall be rated for 125 psi SWP and shall conform to MSS SP-85 and shall be:

- 1) Crane No. 351.
- 2) Jenkins No. 613-B.
- 3) Lunkenheimer No. 1123.
- 4) Nibco No. F-718-B.
- 5) Red and White No. 400.
- 6) Stockham No. G-512.
- 7) Walworth No. 8906-F.
- 8) KITZ No. 76
- 9) Milwaukee 2981A

e. Valves 2-1/2" and larger shall be flanged bronze mounted Class 250 iron body, outside screw and yoke globe valves with bolted bonnets and renewable seat and disc. Valves shall be rated for 250 psi SWP and shall conform to MSS SP-85 and shall be:

- 1) Crane No. 21E.
- 2) Jenkins No. 923.
- 3) Lunkenheimer No. 884.
- 4) Nibco No. F-768-B.
- 5) Stockham No. F-532.
- 6) Walworth No. 8955-F.

7) Milwaukee 2983M

6. Check Valves:

- a. Silent Check Valves: 2-1/2" and larger shall be nonslam type ASTM A126 Class B cast iron body, bronze or stainless steel fitted wafer style spring check valves Valves shall be ASA Class 125/150 rated and shall be:
- 1) Mission Duo-Check II Type.
 - 2) Muessco Sure Check Type.
 - 3) Nibco No. W-920-W.
 - 4) Red and White Fig. No. 442.
 - 5) Stockham No. WG-970.
 - 6) Techno Corporation 5050 Series.
 - 7) Victaulic 711/715.
 - 8) KITZ 7022.
 - 9) Milwaukee 8800.
- b. Swing Check Valves: 2" and smaller for low velocity, nonpulsating applications shall be 150 psi SWP rated all bronze swing check valves with regrinding bronze disc and threaded connections. Valves shall conform to MSS SP-80 and shall be:
1. Crane No. 141.
 2. Jenkins No. 352-C.
 3. Lunkenheimer No. 230.
 4. Nibco No. T-433-B.
 5. Red and White Fig. No. 238.
 6. Stockham No. B-321.
 7. KITZ No. 29.
 8. Milwaukee 508.
- b. Lift Check Valves: 2" and smaller for pulsing applications shall be 150 psi SWP rated all bronze spring loaded lift check valves with renewable composition disc and threaded connections. Valves shall conform to MSS SP-80 and shall be:
- 1) Jenkins No. 655-A.
 - 2) Milwaukee 548T
- c. Swing Check Valves: 2-1/2" and larger shall be 125 psi SWP rated, iron body, bronze fitted swing check valves with regrindable and renewable seats and discs and Class 125 flanged connections. Valves shall conform to MSS SP-71 and shall be:
- 1) Crane No. 373.
 - 2) Jenkins No. 624-C.
 - 3) Lunkenheimer No. 1790.
 - 4) Nibco No. F-918-B.
 - 5) Red and White No. 435.

- 6) Stockham No. G-931.
 - 7) Walworth No. 8928-F.
 - 8) KITZ No. 78
 - 9) Milwaukee
- d. Swing Check Valves: 2-1/2" and larger shall be 250 psi SWP rated, iron body, bronze fitted swing check valves with regrindable and renewable seats and discs and Class 250 flanged connections. Valves shall conform to MSS SP-71 and shall be:
- 1) Crane No. 39-E.
 - 2) Jenkins No. 339-R.
 - 3) Lunkenheimer No. 323.
 - 4) Nibco No. F-968-B.
 - 5) Stockham No. F-947.
 - 6) Walworth No. 8970-F..
 - 7) Milwaukee
- e. All swing check valves shall be installed in vertical piping only. Allow adequate pipe clearance to allow for proper valve operation.

I. HVAC Valves for Service Over 150 PSIG:

[VERIFY REQUIREMENTS]

1. Ball Valves:

- a. Ball valves shall be two piece with a full line size (full port) [**chromium plated brass**] [**316 stainless steel**] balls [**and stems**] [, **brass stems**], and reinforced seats and stuffing box rings. All ball valves shall be designed to permit repacking while valve is in line. Valves shall be furnished with blowoutproof stems. Valves used for balancing shall be provided with balancing stops.
- b. Ball valves 2" and smaller shall be threaded two piece body bronze or brass valves of a [**standard**] [**full**] port design. Valves shall be rated for 300 psi WOG and shall conform to Federal Specification WW-V-35B and shall be:
 - 1) Apollo No. 77-100 [**Standard Port**].
 - 2) Crane No. 903TF [Standard Port].
 - 3) Nibco No. T-585 [**Full Port**].
 - 4) Red and White No. 5044F [**Full Port**].
 - 5) Stockham No. S216-BR-R-T [**Standard Port**].
 - 6) Victaulic 722 [**Standard Port**].
 - 7) KITZ No. 68 Series [**Full Port**]
 - 8) Milwaukee BA 400S
- c. HVAC diversion valves 2" and smaller shall be three-way diversion type ball valves, bronze body, 300 psig nonshock WOG at 200°F, Apollo 70-600 Series or equal.

2. Butterfly Valves:

- a. All butterfly valves shall be full tapped and threaded lug type, manufacturer certified for bubbletight, dead end shut off from either direction at design working pressure and

temperature without need for down stream flange. Valves 2-1/2" through 5" in size shall have lever type operators with memory stops. Valves 6" and larger and all valves requiring chain operators, shall have enclosed, self-locking wheel-operated worm gear type, waterproof, factory-lubricated operators. Gear segment shall be manganese bronze or ductile iron with a steel or ductile iron worm and oil impregnated bronze bushings or worm shaft. Operators shall have built-in adjustable mechanical stops and position indicators. Valves used for balancing shall be certified suitable for continuous throttling service.

- b. Valves 2-1/2" and larger shall be 285 psig nonshock WOG at 200°F, ANSI Class 150 with ductile iron or carbon steel lug body, EPDM (EPT) or TFE replaceable seat, silicon bronze, aluminum bronze or stainless steel disc, 316 or 416 stainless steel upper and lower stems (stems shall be positively connected to the valve disc) and EPDM (EPT) or TFE stem seals or shall have single piece disc core/drive stem of EPDM encapsulated ductile iron. Valves shall be:
 - 1) Centerline No. B285 Series.
 - 2) Dezurik No. 644, L, E, SSI, 3, *.
 - 3) Milwaukee HP1LCS4212 Lever
 - 4) Milwaukee HP1LCS42123 Gear
3. Gate Valves:
- a. Valves 2" and smaller shall be 300 psi SWP rated, all bronze gate valves with solid wedge, union bonnet, inside screw, traveling stem and threaded connections. Valves shall conform to MSS SP-80 and shall be:
 - 1) Crane No. 634E.
 - 2) Jenkins No. 270-U.
 - 3) Nibco No. T-174-A.
 - 4) Stockham No. B-144.
 - 5) Walworth No. 55.
 - 6) KITZ No. 37
 - 7) Milwaukee 1182
 - b. Valves 2-1/2" and larger shall be flanged bronze mounted Class 250 iron body, outside screw and yoke gate valves with bolted bonnets and solid wedges. Valves 4" and larger for steam service shall be provided with warm-up bypass valves. Valves shall be rated for 250 psi SWP and shall conform to MSS SP-70 and shall be:
 - 1) Crane No. 7-1/2E.
 - 2) Jenkins No. 204.
 - 3) Lunkenheimer No. 1436.
 - 4) Nibco No. F-667-0.
 - 5) Stockham No. F-667.
 - 6) Walworth No. 8786-F..
 - 7) Milwaukee 2894A
4. Needle Valves: Valves one inch (1") and smaller shall be Mueller Steam Company Type 21 female-female globe type brass needle valves rated for 500 psi at 150°F and 100 psi saturated steam.

5. Globe Valves:

- a. Valves 2" and smaller shall be 250 psi SWP rated, all bronze globe valves with renewable disc, screw over or union bonnet and threaded connections. Valves shall conform to MSS SP-80 and shall be:
 - 1) Crane No. 229-C.
 - 2) Jenkins No. 801.
 - 3) Nibco No. T-275-Y.
 - 4) KITZ No. 18
 - 5) Milwaukee 572
- b. Valves 2" and smaller for bypass or throttling service shall be 300 psi SWP rated, all bronze globe valves with renewable-regrindable stainless steel plug disc, and seat ring, union bonnet and threaded connections. Valves shall conform to MSS SP-70 and shall be:
 - 1) Crane No. 382P.
 - 2) Jenkins No. 556-P.
 - 3) Lunkenheimer No. 16-PS.
 - 4) Nibco No. T-276-AP.
 - 5) Stockham No. B-74.
 - 6) Walworth No. 3260-P.
 - 7) KITZ No. 17S
 - 8) Milwaukee 593A
- c. Angle and Y-pattern globe valves corresponding to the standard globe valve models specified above may be used where more suited to the installation location.
- d. Valves 2-1/2" and larger shall be flanged bronze mounted Class 250 iron body, outside screw and yoke globe valves with bolted bonnets and renewable seat and disc. Valves shall be rated for 250 psi SWP and shall conform to MSS SP-85 and shall be:
 - 1) Crane No. 21E.
 - 2) Jenkins No. 923.
 - 3) Lunkenheimer No. 884.
 - 4) Nibco No. F-768-E.
 - 5) Stockham No. F-532.
 - 6) Walworth No. 8955-F.

6. .Check Valves:

- a. Silent Check Valves: Valves 2-1/2" and larger shall be nonslam type ASTM A126 Class B cast iron body, bronze or stainless steel fitted wafer style spring check valves with renewable seats and discs. Valves shall be ASA Class 250/300 rated and shall be:
 - 1) Mission Duo-Check II Type.
 - 2) Muessco Sure Check Type.
 - 3) Nibco No. W-960-B.
 - 4) Stockham No. WG-970.

- 5) Techno Corporation 5050 Series.
- b. Swing Check Valves: Valves 2" and smaller shall be 300 psi SWP rated all bronze swing check valves with regrinding bronze disc and threaded connections. Valves shall conform to MSS SP-80 and shall be:
 - 1) Crane No. 76E.
 - 2) Jenkins No. 762-A.
 - 3) Lunkenheimer No. 624.
 - 4) Nibco No. T-473-B.
 - 5) Stockham No. B-364.
 - 6) Walworth No. 3428.
 - 7) KITZ No. 19
 - 8) Milwaukee 507
- c. Swing Check Valves: Valves 2-1/2" and larger shall be 250 psi SWP-rated, iron body, bronze fitted swing check valves with regrindable and renewable seats and discs and Class 250 flanged connections. Valves shall conform to MSS SP-71 and shall be:
 - 1) Crane No. 39-E.
 - 2) Jenkins No. 339-R.
 - 3) Lunkenheimer No. 323.
 - 4) Nibco No. F-968-B.
 - 5) Stockham No. F-947.
 - 6) Walworth No. 8970-F.
 - 7) Milwaukee 2970M
- d. All swing check valves shall be installed in vertical piping only. Allow adequate pipe clearance to allow for proper valve operation.

[VERIFY REQUIREMENTS]

- J. Automatic Flow Control Valves: Flow control valves shall be factory-calibrated, direct acting, automatic pressure compensating type. Each valve shall limit flow rates to within _5% accuracy, regardless of system pressure fluctuations. Valve control mechanism shall consist of a tamperproof, stainless steel cartridge assembly with open chambers and unobstructed flow passages. Cartridge assembly shall include a self-cleaning, spring-loaded moving cup guided at two separate points and shall utilize the full available differential pressure to actuate without hysteresis or binding. Four differential pressure ranges shall be available with the minimum range requiring less the 2 psig. Each valve to be provided with a metal tag, chain and stamped for system identification. Pressure taps and quick disconnect valves shall be provided with ferrous bodies. All hydronic system flow control valves shall be of one manufacturer.
- K. Valves for Automatic Water Make-up Connections: Valves 2" and smaller shall be Jenkins Fig. No. 900T or equal. Valves 2-1/2" and larger shall be Jenkins Fig. No. 632B, No. 632E or equal butterfly valve with operator.
- L. Relief Valves: The pressure relief valves installed for the protection of the water circulating circuits shall be McAlear No. 307 single seated diaphragm and spring type valves with screwed connections or approved equal. They shall be 3/4" size of bronze construction with bronze seat, composition shut-off disc and rubber diaphragm. Pressure relief valves for closed water systems shall be ASME-rated pressure relief valves sized as required for the intended service.

M. Refrigerant Valves and Specialties:

1. Valves and specialties shall be as manufactured by Mueller, Sporlan or an approved equal and shall be as follows:
 - a. Refrigerant Shut-off Valves Mueller Series A-15250, size as required.
 - b. Refrigerant Strainers Sporlan Type 10000 "Y", size and type as required.
 - c. Refrigerant Relief Valves Mueller Safety master, size and type as required.
 - d. Filter/Dryers Sporlan "Catch-All" scaled type, size as required.
 - e. Sight-glass-moisture Indicator Sporlan "See All", size as required.
 - f. Solenoid Valves Sporlan Type A3, size as required.
 - g. Thermostatic Expansion Valves Sporlan, size and type as required.
2. Not all of the above specialties are required on all systems, but all systems shall have shut-off valves, a relief valve, a filter/dryer and a sight-glass-moisture indicator. Where such items are furnished unit mounted on equipment, they may be deleted from the external piping circuit with the following exception:
 - a. A filter/dryer shall always precede a solenoid valve in the liquid line.
 - b. Charging valves in equipment shall not be construed as alternates to shut-off valves.

2.2 STRAINERS

A. General: Strainers shall be as follows:

1. 150 PSIG Working Pressure Water Strainers: 150 psig working pressure, 2" and smaller, shall be Muessco No. 11 or equal, 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 or equal, 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, and Class 125 ANSI B16.1 flanged ends. Blowdown valves shall be full port ball valves.
2. 300 PSIG Working Pressure Water Strainers: 300 psig working pressure, 2" and smaller, shall be Muessco No. 11 or equal, 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 or equal, 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, and Class 250 ANSI B16.5 flanges. Blowdown valves shall be full port ball valves.
3. 150 PSIG Working Pressure Duplex Basket Water Strainers: 150 psig working pressure, 3" and smaller, Muessco #692 Series or equal, 200 psi WOG cast iron body, 150 pound ANSI B16.1 flanges, dual 40 mesh stainless steel strainer baskets, diverter valve. Blowdown valves shall be full port ball valves.
4. 150 PSIG Working Pressure Steam Strainers: 150 psig working pressure, 2" and smaller, shall be Muessco No. 11 or equal, 250 pound steam, 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. 752 or equal, 250 pound steam, perforated monel screen with 1/16" perforations for sizes through 4", and 5/32" perforations for 5" and above, with blowdown connection, and Class 250 ANSI B16.5 flanged ends. Blowdown valves shall be full port ball valves.

- B. Pump Suction Diffusers: Provide Taco Series 300 or approved equal 150 psi WOG pump strainer/suction diffusers. Diffusers shall consist of an angle body with inlet vanes and a combination **[monel] [304 stainless steel]** diffuser strainer with 3/16" diameter openings. Flow direction shall be from inside the strainer to outside. The diffuser body shall fit the pump and connecting piping size and shall be provided with an adjustable support foot. Suction diffusers shall be factory-drilled

and tapped for field-installation of a pressure gauge and gauge cock as shown on the drawings. Where suction diffusers are provided, strainers may be omitted. Blowdown valves shall be full port ball valves.

2.3 UNIONS:

- A. General: Provide and install in lines assembled with screwed and soldered fittings at points of connection to items of equipment and elsewhere as indicated or required to permit proper connections to be made or so that equipment may be removed. Unions shall also be provided in welded lines at the connections to items of equipment, where flanges are not provided.
1. Unions in steel lines assembled with screwed fittings shall be malleable iron screwed pattern unions with bronze seats. Unions in copper or brass lines shall be all brass, threaded pattern unions. Where unions are required by the above in steel lines assembled by welding, they shall consist of two mating welding flanges.
 2. Dielectric unions shall be used at all junctures of dissimilar metals.
 3. Unions in 2" and smaller in ferrous lines shall be Class 300 AAR malleable iron unions with iron to brass seats, and 2-1/2" and larger shall be ground flange unions. Unions in copper lines shall be 125 pounds ground joint brass unions or 150 pounds brass flanges if required by the mating item of equipment. Companion flanges on lines at various items of equipment, machines and pieces of apparatus shall serve as unions to permit removal of the particular items. See particular Specifications for special fittings and pressure.

2.4 FLANGES:

- A. General: All 125/150 pound and 250/300 pound ANSI flanges shall be weld neck and shall be domestically manufactured, forged carbon steel, conforming to ANSI B16.5 and ASTM A181 Grade I or II or A-105-71 as made by Tube Turn, Hackney or Ladish Company. Slip on flanges will not be acceptable. Each fitting shall be stamped as specified by ANSI B16.9 and, in addition, shall have the laboratory control number stenciled on each fitting for ready reference as to physical properties and chemical composition of the material. Complete test reports may be required for any fitting selected at random. Flanges which have been machined, remarked, painted or otherwise produced domestically from imported forgings or materials will not be acceptable. The flanges shall have the manufacturer's trademark permanently identified in accordance with MSS SP-25. Submit data for firm certifying compliance with these Specifications. Gaskets used shall be ring form, dimensioned to fit accurately within the bolt circle, shall be 1/16" thick, Manville service sheet packing Style 60. Inside diameter shall conform to the nominal pipe size. Bolts used shall be carbon steel bolts with semi-finished hexagon nuts of American Standard Heavy dimensions. All-thread rods must be approved on a case-by-case basis. Bolts shall have a tensile strength of 60,000 psi and an elastic limit of 30,000 psi. Flat faced flanges shall be furnished where required to match flanges on pumps, check valves, strainers, and similar items. Only one manufacturer of weld flanges will be approved for each project.

2.5 GASKETS:

- A. General: Gaskets shall be placed between the flanges of all flanges joints. Such gaskets shall be ring form gaskets fitting within the bolt circle of their respective flanges. Gaskets shall be 1/16" thick Manville Service Sheet Packing Style 60. The inside diameter of such gaskets shall conform to the nominal pipe size and the outside diameter shall be such that the gasket extends outward to the studs or bolts employed in the flanged joint.

2.6 FLEXIBLE CONNECTIONS:

- A. General: Refer to Section 15250, "Vibration Isolation", for flexible connections.

2.7 FLEXIBLE HOSE:

- A. General: Provide flexible hose in piping systems where shown on the Drawings or specified under Division 15.
- B. Flexible Hose: Provide pressure rated, wire helix reinforced, flexible, insulated rubber hose kits for final chilled water connections to CRAC units as shown on the Drawings. Hose kits shall be fabricated in lengths as required to suit site conditions, 20' maximum, with ANSI Class 150 flanged connections at both ends. Coordinate flange pattern with existing flanges on site. Hose kits shall be nominal 2-1/2" pipe size. Flange end fittings, hose connection fittings and hose shall be pressure rated as a unit for a minimum of 150 psi standard operating pressure, 275 psi minimum burst pressure and 275 psi minimum hose/fitting leak or separation. Hoses shall be insulated using 1/2" elastomeric insulation with a continuous vapor barrier. Insulation shall have a maximum flame spread of 25 and a maximum smoke developed of 100, as installed. Hoses shall be installed and supported as recommended by the manufacturer. Hoses shall be manufactured by Motion Industries (713/675-1852, contact David Lockridge) HoseTex, Texas; Houston, Inc., Houston, Texas; Allied Hose and Specialty Company, Houston, Texas; Coastal Rubber Company, Houston, Texas; Houston Gasket, Houston, Texas or an approved equal. Details of all components and hose kits construction shall be submitted for approval prior to fabrication.

2.8 HOSE BALANCING KITS:

- A. General: Provide an automatic balancing hose kit for each **[heating hot water and]** chilled water connections to fan coil units **[and heating hot water connections to HVAC Terminal Units]**. Hoses shall be flexible stainless steel braided hose, minimum length of 24" and shall have brass swivel end connection a minimum of 3/4" MPT suitable for a pressure differential of 4 psi through 57 psi and a flow rate range of 1.0 through 10.0 gpm.
- B. Components: Each automatic balancing hose kit shall consist of a return hose with a 3/4" bronze ball valve, a 3/4" automatic flow control valve with two P-T test plugs, a 3/4" x 24" long flexible stainless braided hose with 3/4" MPT brass swivel end and a supply hose with a 3/4" bronze ball valve a 3/4" P-T Adaptor connector with a P-T Test plug, a 3/4" bronze Wye-strainer with built-in drain valve, a 3/4" x 24" long flexible stainless braided hose with 3/4" MPT brass swivel adapter.
- C. Ratings: Hose kits shall meet flame retardant testing standards similar to UL No. 723, NFPA No. 255, ANS No. 3.5, UBC No. 42-1 and ASTM E84. Manufacturer shall provide independent laboratory tests verify compliance with these standards or UL-listing and label for flame spread zero (0) and smoke density zero (0). Minimum pressure and temperature rating of automatic hose balancing kits shall be 200 psig at 230°F.
- D. Control Valves: Automatic Flow Control Valves shall automatically control flow rates with _5% accuracy. Valve control mechanism shall consist of a passivated stainless steel cartridge with a ported cup, segmented orifices and full travel linear coil spring and a ductile iron housing with 1/8" FPT taps for P.T. plugs. The inner tube is a nontoxic synthetic polymer suitable for water temperatures from 5°F to 230°F. The tube has an outer covering of braided stainless steel. Y-Strainer-Bronze Body with stainless steel cylinder screen, 0.055" diameter holes.
- E. Manufacturers: Automatic Balancing hose kits shall be as manufactured by Griswold Controls or approved equal.
- F. Meter: Provide a differential pressure meter calibrated for flow in gpm for initial balance as well as for the Engineer to verify balance. This meter shall be turned over to the Owner during the Owner training period.

2.9 COMPRESSION/EXPANSION TANKS:

- A. General: Provide a diaphragm-type pre-pressurized expansion tank with replaceable bladder. Each tank shall accommodate the expanded/compressed water of the connected system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. It shall maintain minimum operating pressure necessary to eliminate all air. The only air in the system shall be the permanent

sealed-in air cushion contained in the diaphragm-type tank. Tank size shall be as indicated on the drawings.

- B. Tanks: Provide 125 psig or greater, ASME construction, expansion, compression tanks complete with drain fitting, lifting lugs, base ring, pipe connections, and charging connection. Pressure rating shall be compatible with the system pressure. The tank shall be a diaphragm-type, hydroneumatic expansion/ compression tank designed for the indicated services. The tank shall be constructed of welded steel and equipped with a flexible, replaceable diaphragm to maintain a separation between the system water and the air cushion. The outside of each tank shall be factory-painted with a primer and two coats of enamel after fabrication. Each tank shall bear an appropriate ASME label for the system working pressures and temperatures.
- C. Manufacturers: Tanks manufactured by Amtrol, Armstrong, Taco, or Woods Industrial and meeting the above specifications will be acceptable.

2.10 AIR ELIMINATION:

- A. Air Separators (Tangential Type): All free air originally contained in each closed water system, and all entrained air bubbles carried by system water shall be eliminated by air separator system points as indicated on the Drawings. Air separators shall have removable stainless steel strainers.
- B. Construction: The air separator shall be cast iron or welded steel, constructed, tested and stamped in accordance with Section VIII of the ASME Code for a working pressure of 125 psi as manufactured by Amtrol, Taco, Woods Industrial or approved equal.

2.11 AIR VENTS:

- A. General: Provide Sarco Type 13W, 150 psig working pressure, Sarco Type 13WH, 300 psig working pressure or equal 3/4" inlet automatic air vents with cast iron body, bronze pilot mechanism and stainless steel hardware. Air vents shall be rated for the working pressure at the point of installation.
- B. Operation: Valves shall provide a high air removal rate at low pressure differentials and shall tightly seal to prevent system water loss and to prevent entrance of air in negative pressure situations.
- C. Isolation Valves: Provide an isolation valve for each air vent to facilitate maintenance.

2.12 STEAM SPECIALTIES:

- A. Steam Pressure Reducing Valves: Provide self-operated external pilot type, single-seated, metal diaphragm actuated pressure reducing valves, Spence Type ED, 150 psig Pressure Regulators, or approved equal. These valves shall regulate accurately throughout the range of pressure and flow conditions scheduled. They shall function quietly and shut tight on a dead end shutoff. Bodies shall be cast iron; sizes of 2-1/2" and larger shall have flanged ends. Seats, discs, stems and diaphragms shall be of stainless steel. There shall be no springs in the path of the stem and no stuffing boxes. All parts must be easily accessible without removal of the valve from the line. The pilot valve shall be separate from the main valve and connected to it by unions. A strainer screen shall be built in the pilot inlet. Pilots shall be interchangeable on all sizes of main valves. Valves shall be sized so as to limit the noise level to 90 dba or less and to limit the steam velocity to 900 fpm. Utilize a muffling orifice or noise suppressor in conjunction with the valve when shown on the drawing or when necessary to minimize noise levels.
- B. Steam Muffling Orifices: Provide Penn Model "SP", Spence, or approved equal single pass silencers, designed provide 6 dB to 10 dB attenuation.
- C. Steam Noise Separators: Provide Penn Model "SP" or approved equal single pass silencers, designed to provide maximum attenuation of both low and high frequency noise with an overall reduction capability of 34 dB. The silencer shall be of the three stage chamber design with 1/2" Dalcon acoustical material, protected by perforated plate in the first chamber. The silencer shall handle maximum velocities of 900 fps with a pressure drop of no more than 1.5 psig.

- D. Steam Relief Valves: Provide Kunkle Figure 6021 (2" and smaller) or 252 (2-1/2" and larger) or approved equal ASME Standard, National Board Certified safety/relief valves. The pressure at which each relief valve shall open is designated on the Drawings. When such valves are ordered, order shall specifically include the pressure at which each relief valve shall be set. Each valve shall have a metal tag attached stamped with the valve identification plus the pressure setting.
- E. Steam Safety Valve Discharge Elbows: All vent lines from steam relief valves shall be provided with safety valve discharge elbows at the point at which such lines rise to an elevation higher than that of the safety valve. The nature and design of the piping systems involved shall be such as to drain effectively all condensate from the discharge side of all relief valves. These safety valve discharge elbows shall be Grinnell Company's Safety Valve Drip Pan Elbows Figure No. 1538F, Kunkle Figure No. 299 or approved equal. No force shall be exerted on the safety valve by the discharge piping.
- F. Steam Traps:
1. Float and Thermostatic Traps: Cap and body shall be ASTM A278, Class 30 cast iron. Entire trap mechanism shall be attached to the cap. Float and mechanism shall be stainless steel with heat treated chrome steel valve. The float shall be Heliarc-welded to avoid introduction of dissimilar metals. The thermostatic air vent shall be balanced pressure phosphor bronze disc diaphragm type or beryllium copper bellows caged in stainless steel. Where noted, provide integral vacuum breaker. Traps are to be Armstrong Series B, J, or K or approved equal.
 2. Inverted Bucket Traps: Cap and body shall be ASTM A278, Class 30 or equal cast iron. Internal mechanism is to be of a free floating guided lever design. The mechanism and bucket to be of stainless steel with heat-treated chrome steel valve. Provide bi-metal thermic vent when noted. Provide trap with integral strainer and blowdown connection. Traps are to be Armstrong 800 & 880 Series or approved equal for in-line piping or 200 Series for bottom-in, top-out piping.
- G. Steam Discharge Head/Muffler:

[INSERT TEXT TO SUIT PROJECT REQUIREMENTS]

- H. Steam Vent Flapper Valve: Provide a cast iron flapper valve assembly as detailed on the Drawings, where steam relief vent piping discharges through a wall.
- I. Flash Tanks: Tanks shall be built as per the requirements of Section VIII of the ASME code and stamped by the National Board of Pressure Vessel Inspectors for a design pressure of 125 psig. Vessels shall be constructed of black steel and shall contain all inlets, outlets and internal baffles to provide adequate separation of the high pressure condensate returns into low pressure flash steam and hot water. Inspection openings shall be provided on flash tanks 18" in diameter through 36" in diameter. Manways shall be provided on flash tanks in excess of 36" in diameter. Inspection openings shall not be required on tanks less than 18" in diameter. Vessel exterior shall be given one coat of primer at the factory prior to shipment.

2.13 PIPE EXPANSION JOINTS:

- A. Split Type Joints: Provide slip type pipe expansion fittings in [steam] [and pumped condensate] piping mains at locations shown on the Drawings. Expansion joints shall be Advanced Thermal Systems, Inc. Series **[TP2F]**, Hyspan, or an approved equal and shall be 150 pound flanged packed single or double slip type expansion joints designed for packing injection under full line pressure of self-lubricating teflon/asbestos injectable packing. The injectable packing shall be contained by a minimum of three 1/2" square self-lubricating containment rings each side of the injectable packing zone. The packing area in contact with the joints sliding slip shall be a minimum of sixteen times the joint nominal pipe size. Expansion joints shall be designed for 150 psig - 500°F and have 150 pounds ANSI flanged ends.
1. Expansion joints shall have a minimum of three packing injection cylinders with mating plungers. Packing injection cylinders shall be a minimum 2" diameter with heavy duty internal acme thread.

"V" threads not acceptable. Minimum shear area of the carbon steel plungers shall be 0.5 square inches. Packing cylinders to be welded in place prevent accidental disengagement.

2. Pressure containing components of each joint shall be machined from seamless steel A-53 Gr B pipe or equivalent tubing with the traverse chamber having a standard wall thickness. No longitudinal welds allowed and no lap welds allowed.
 3. Slip shall be machined from A-53 Gr B Schedule 80 seamless pipe. Slips shall be ground and polished to a 16 RMS finish prior to chrome plating.
 4. Sliding slips shall be plated with a duplex chrome plate consisting of one mil of crack-free hard chrome and certified by Permascope inspection per ASTM B499.
 5. The internal end of all slips shall be provided with stainless steel outward limit stops fully welded in place and designed to prevent slip disengagement in event of an anchor failure.
 6. Provide a minimum of two spare packing plugs of injectable packing minimum 5/8" diameters x 7/8" long or equivalent volume for each packing cylinder.
 7. The joints internal and external guide shall be equipped with bronze filled teflon Inserts to protect the sliding slip from scoring. The bronze filled teflon inserts shall be capable of compressing under a load caused by severe misalignment in order to prevent slip from binding. Metal inserts or guides surfaces shall not be acceptable.
 8. Packing for steam piping shall be Code No. 350H reinforced graphite. Packing for steam condensate shall be Code No. 200H fiberglass/rubber/teflon.
- B. Bellows Type Joints: Provide bellows type pipe expansion fittings in **[steam relief]** piping at locations shown on the Drawings. Expansion couplings shall be stainless steel with 150 pound flanged connections and shall be suitable for a 225 psi design pressure. Expansion couplings shall be as manufactured by Flexible Metal Hose Company, Flexonics, Inc., Hyspan, or an approved equal. Piping shall be securely anchored between each pair of expansion joints as recommended by the joint manufacturer. Expansion fittings shall be as follows:
1. Type "A" shall be single control flexible low corrugation stainless steel type with mated neck rings and control rings and pipe alignment guides for piping on either side of the expansion joint.
 2. Type "B" shall be dual control flexible low corrugation stainless steel type with a pipe anchor coupling between the two expansion couplings and pipe alignment guides for piping on either side of the expansion joint.
- C. Testing: Each expansion coupling shall be hydrostatically tested by the manufacturer at 225 psi prior to shipment.
- D. Sizing: Axial movement available at each expansion coupling shall be equal to or greater than that scheduled on the Drawings.
- E. Pipe Guides: Piping on either side of expansion couplings and elsewhere where noted on the Drawings shall be supported with pipe alignment guides as recommended by the expansion joint manufacturer. The guides shall allow free axial movement while limiting lateral and angular movement. Primary and secondary guides shall be located as shown on the Drawings and per the manufacturer's recommendations. Additional guides shall be provided as recommended by the coupling manufacturer.
- F. Insulation: Provide a removable, reusable and weather resistant insulation blanket for each joint. Blankets shall be 4" thick for steam applications and 2" thick for steam condensate, condensate vent, and steam relief applications.

2.14 GAUGES AND THERMOMETERS:

- A. General: Provide gauges and thermometers for monitoring HVAC systems as shown on the Drawings and specified herein.

- B. **Gauges:** Gauges shall be Ashcroft, Terrice, Weksler, Moeller, or U.S. with 4-1/2" dial face, phenol case, stainless steel movement with Grade A phosphor bronze bourdon tube and micrometer-type calibration adjustment screw. Accuracy shall be 1/2 of 1% of full scale. Provide a Crane No. 88 or equal needle valve gauge cock **[and pulsation dampener]** in pressure tube to gauge. **[Provide coil syphons for all steam gauges.]** Gradation shall be one pound or less.
- C. **Thermometers:** Thermometers shall be Terrice, Weksler, Moeller, or Scientific red-reading mercury-type with 9" case, maximum 2°F scale divisions, 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. Adjustable angle thermometers will not be acceptable.
- D. **Thermometer Wells:** Thermometer wells shall be brass or stainless steel with pressure and temperature ratings suitable for their application. Wells for insulated piping shall have a 2-1/2" lagging protrusion. Locate thermometer wells so the sensing bulb will give a true and correct reading. Install thermometer wells 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. All wells shall be filled with silicon and complete with caps and chains. Thermometer wells shall be installed on a 45 degree angle into the direction of water flow in the monitored piping. Thermometers and wells shall have the following insertion lengths:

<u>Diameter</u>	<u>Pipe Orientation</u>	<u>Insertion Length</u>
4"	Horizontal	2-1/2"
4", 6"	Vertical	5"
6", 8"	Horizontal	5"
8", 10"	Vertical	8"
>8"	Horizontal	8"
>10"	Vertical	14"

- E. **Range and Gradations:** 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 not 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. Chilled water 0°F to 100°F.
 2. Condenser water 30°F to 130°F.
 3. Heating water 30°F to 240°F.
 4. Steam 100°F to 550°F.
 5. Glycol 30°F to 180°F.

[VERIFY REQUIREMENTS]

- F. **Gauge Locations:** Provide pressure gauges at the following locations:
 1. Suction side of each pump inlet suction diffuser or strainer.
 2. Suction side of each pump.
 3. Discharge side of each pump.
 4. Entering water side of each heat exchanger.
 5. Leaving water side of each heat exchanger.
 6. Entering steam side of each steam pressure reducing station.

7. Leaving steam side of each steam pressure reducing station stage.
8. **[Entering water side of each air handling unit preheat and chilled water coil.]**
9. **[Leaving water side of each air handling unit preheat and chilled water coil.]**
10. Where shown on the Drawings.

[VERIFY REQUIREMENTS]

G. Thermometer Locations: Provide thermometers and thermometer wells at the following locations:

1. Entering chilled water at each chiller.
2. Leaving chilled water at each chiller.
3. Entering condenser water at each chiller.
4. Leaving condenser water at each chiller.
5. Entering hot water at each hot water boiler or heat exchanger.
6. Leaving hot water at each hot water boiler or heat exchanger.
7. Chilled water supply main to building.
8. Chilled water return main from building.
9. Hot water supply main to building.
10. Hot water return main from building.
11. Entering hot water at each shell and tube heat exchanger.
12. Leaving hot water at each shell and tube heat exchanger.
13. **[Chilled water supply to each air handling unit chilled water coil.]**
14. **[Chilled water return to each air handling unit chilled water coil.]**
15. **[Hot water supply to each air handling unit heating coil.]**
16. **[Hot water return from each air handling unit heating coil.]**
17. Where shown on the Drawings.

[VERIFY REQUIREMENTS]

H. Pressure and Temperature Test Taps: Taps shall be provided at the supply, bypass and return connections to all coils and at other locations as shown on the drawings. Taps shall be Peterson Engineering "Pete's Plugs", 1/2" NPT, brass with Nordel core, and color-coded cap and gasket, Model 170 or equal. Provide the Owner with **[six]** [] pressure gauge adapters with gauges and probes and **[six]** [] 5" stem pocket testing thermometers, **[three]** [] 25°F to 120°F and **[three]** [] 0°F to 220°F.

2.15 BTU METERING:

- A. General: Provide a Btu metering system to monitor **[chilled water]** energy consumption as shown on the Drawings. Btu metering shall be accomplished **[with a true Btu meter [as specified in Section] [15901, "Pneumatic Temperature Controls".] [15902, "Electric Temperature Controls".] [with a water meter to measure water flow which will be used to approximate Btu consumption.]**
- B. BTU Meters: The chilled water Btu metering system shall be a Hersey Model **[BT-003-4" CW]** [] or approved equal system with a Model 7001 Totalizing Btu Calculator, Model **[MVR-650-4"]** [] Industrial Turbine Water Meter and Monolithic Temperature

Sensors. Water meter shall be 150 psig flange connected and shall have a maximum of **[4 psig]** **[_____ psig]** pressure drop at **[300 gpm]** **[_____ gpm]** flow. All Btu metering shall be installed complete with all required wiring and accessories.

- C. Water Meter: Provide a Hersey Model MVR or an approved equal turbine water meter with all bronze case, polypropylene rotor, magnetic drive, a UL-approved strainer and a continuous pulse output. Meter accuracy shall be within AWWA Standards at flow rates from **[10 to 650 gpm]**. **[The pulse output shall be suitable for flow rate input to _____.]**

2.16 FLOW VENTURIS:

- A. General: Provide Olympic Valve Company or approved equal balancing and flow measuring venturis for measuring system water flow at locations shown on the Drawings.
- B. Flow Measurement, Sizes 2-1/2" and Larger: Provide full line size, flanged cast iron or carbon steel flow venturis, with two dual-core pressure/temperature parts. Venturis shall be rated at 150 psi or 300 psi WOG as required to suit the system working pressure at the point of installation.
- C. Balancing/Flow Measurement, Sizes 4" and Smaller: Provide Olympic Valve Company Flowset or approved equal matching valves for each application. Isolation/flow measurement valves shall consist of a 300 psig WOG full port ball valve, flow venturi with two pressure/temperature test parts and a union. Isolation/balancing valves shall consist of a linearized 300 psig WOG ported butterfly valve, a pressure/ temperature test port and a union.
- D. Flow Meter: Provide an Olympic meter kit or approved equal case mounted differential pressure meter with gauge faces for direct gpm readout with each venturi/valve type on the project and necessary hose, valves and accessories required for use.
- E. Accuracy: Flow measurement accuracy for the complete system under field conditions shall be 3%.

2.17 DRAIN PANS:

- A. General: Provide 3" deep galvanized sheet metal auxiliary drain pans under any equipment where shown on the drawings and under all horizontal air handling units, duct mounted chilled water coils, horizontal suspended fan coil units and suspended domestic water heaters located above ceilings.
- B. Construction: Drain pans shall be minimum 16 gauge galvanized steel with water tight soldered joints. Drain pans shall be at least 2" larger in each dimension than the equipment served and shall extend under control and isolation valves. Chain suspend drain pans under equipment served. Pan shall have a welded coupling of the same size as the unit condensate drain (minimum 3/4" FPT). Pan bottom shall be cross-broken and sloped to the drain connection.
- C. Drain Lines: Auxiliary drain lines shall be routed through the ceiling in "tell-tale" fashion above a general use plumbing lavatory or janitors sink. A chrome plated escutcheon shall be provided. Locations of "tell-tale" drains shall be approved by the Architect.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Except as otherwise indicated, comply with the following requirements.
- B. Isolation Valves: Provide isolation valves at each runout to a piece of equipment 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. All valves shall be located so as to make the removal of their bonnets possible. All flanged valves shown in the horizontal lines with the valve stem in a horizontal position shall be positioned so that the valve stem is inclined one bolt hole

above the horizontal position. Screw pattern valves placed in horizontal lines shall be made up with their valve stems inclined at an angle of 30 degrees above the horizontal position. All valves must be true and straight at the time the system is tested for final acceptance. Valves shall be installed as nearly as possible in the locations as shown on and Drawings. Any change in valve location must be so indicated on the As-built Drawings.

- D. Valve Chain Operators: In central plant and in fan or mechanical rooms where 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: Provide access doors or panels as required to provide full valve access. Refer to Section 23 03 00, "Basic Materials and Methods", for additional requirements.

3.2 STRAINERS:

- A. General: Install strainers ahead of each control valve, steam trap and pressure reducing valve and at other locations shown on the Drawings.
- B. Orientation: Install strainers to allow for easy blowdown and so that strainer baskets can be removed for cleaning.
- C. Strainer Blowdown: Provide a blowdown valve with hose connection and cap at each strainer for blowdown.
- D. Cleaning: Strainers shall be cleaned after initial start-up, after 30 days of operation, and at final acceptance. Contents of the strainer at the 30 day cleaning shall be submitted to the Engineer for review.

3.3 COMPRESSION/EXPANSION TANKS:

- A. General: Install tanks on reinforced concrete housekeeping pads or suspended from the structure with not less than two saddles with two stems per saddle.
- B. Piping: Pipe tanks as detailed on the Drawings.
- C. Charging: Prior to filling each tank, verify tank has been properly charged to a pressure approximately 5 psi above the system pumped pressure at the point of connection.

3.4 AIR VENTS:

- A. General: Install air vents at the top of the air separator, at all system high points, and at all other locations where necessary to remove air from piping systems.
- B. Piping: Install isolation valves in the piping connection to all air vents. Extend a drain line from each air vent to a suitable drain in an accessible location.
- C. Location: Whenever possible, cluster air vents and their drain lines in common locations.

3.5 RELIEF VALVES:

- A. General: Install pressure relief valves for each closed water system. Extend a relief line sized at the full size of the valve discharge, to an accessible drain location.

3.6 STEAM TRAPS:

- A. General: Provide steam traps in all steam distribution piping. Steam distribution piping shall use inverted bucket traps preceded by a "Y-strainer" with blowdown valve, isolation valves for service, and check valve down stream from trap when elevating condensate for return or entering pumped condensate mains. Traps shall be sized to handle condensate at a minimum of three times the expected steam condensing rates.

- B. Types: Provide inverted bucket steam traps at all steam-operated equipment being connected to by this Contractor, except at heat exchangers. Provide float and thermostatic traps at all heat exchangers being connected by this Contractor.
- C. Sizing: Trap sizing for modulating pressure control shall be as follows:
1. 0-15 psig - 2:1 at 1/2 psi pressure differential.
 2. 16-30 psig 2:1 at 2 psi pressure differential.
 3. Above 30 psig 3:1 at 1/2 of the maximum pressure differential across the trap. Constant pressure control use 2:1 safety factor at operating pressure differentials.
- D. Safety Factor: Apply the proper safety factor to the actual condensing rate and size the trap to handle the safety factor load at the recommended pressure differential.
- 3.7 IDENTIFICATION:
- A. Refer to Section 23 03 00 for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 20 10

SECTION 23 22 13 – STEAM AND STEAM CONDENSATE PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install steam and condensate pipe, valves and fittings indicated by the Contract Documents with supplementary items necessary for the proper installation of the steam and condensate piping systems.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references and as noted in this Section:
 - 1. ANSI/ASME SEC 9 - Welding and Brazing Qualifications.
 - 2. ANSI/ASME SEC B31.9 - Building Services Piping.
 - 3. ANSI/AWS D10.12 – Guide for Welding Mild Steel Pipe.
 - 4. ASTM A234 – Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.

1.04 QUALITY ASSURANCE

- A. Valve manufacturer's name and pressure rating shall be marked on valve body.
- B. All valves of the same type shall be provided from same manufacturer.
- C. All fittings of the same type (threaded or welding) shall be provided from same manufacturer.
- D. All flanges shall be from same manufacturer.
- E. Welding Materials and Procedures: Conform to Chapter V, ANSI/ASME SEC B31.9 and applicable state labor regulations.
- F. Welders Certification: In accordance with ANSI/AWS D10.12.

1.05 SUBMITTALS

- A. Product Data:
 - 1. Include data on pipe materials, pipe fittings, valves, and accessories.

B. Record Documents:

1. Include welder's certification of compliance with ANSI/AWS D10.12 and ANSI/ASME B31.9.
2. Submittal data for all fittings and flanges shall include a letter signed by an official of the manufacturing company certifying compliance with these Specifications.

PART 2 - PRODUCTS

2.01 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. Wall, Floor and Ceiling Plates:

1. Provide chrome-plated brass floor and ceiling plates.

C. Piping System Classification:

1. Piping systems designed for steam pressure below 25 psig are low-pressure steam systems. Piping systems designed for steam pressures from 25 psig up to and including 125 psig are medium-pressure steam. Systems 126 psig and above are high-pressure steam.
2. Distribution piping complying with Thermal Energy Cooperative (TECO) requirements is considered high-pressure steam.

D. Piping Materials:

1. Sizes as scheduled and shown on the Drawings are nominal pipe sizes unless otherwise indicated.
2. All pipe and fittings shall be manufactured by a domestic company.
3. All brass and bronze piping components shall have no more than 15 percent zinc content.

E. Threaded Fittings:

1. All threaded fittings shall be USA factory made wrought carbon or alloy steel threaded fittings conforming to ASTM A234 or malleable iron threaded fittings conforming to ASME/ANSI B16.3.
2. Manufacturers: Grinnell, Tube Turn, Weld Bend Hackney, Taylor Forge, Ladish Company.
3. Each fitting shall be stamped as specified by ANSI B16.3.

F. Welded Fittings:

1. All weld fittings shall be USA factory made wrought carbon steel, butt welded fittings conforming to ASTM A234 or ASME B16.9.
2. Manufacturers: Grinnell, Tube Turn, Weld Burn Hackney, Taylor Forge, Ladish Company.
3. Each fitting shall be stamped as specified by ANSI B31.9.

G. Flanges:

1. All 150 lb. and 300 lb. ANSI flanges shall be weld neck and shall be domestically manufactured, forged carbon steel, conforming to ANSI B16.5 and ASTM A1-191 Grade I or II or A-105 as made by Tube Turn, Hackney or Ladish Company. Slip on flanges shall not be used. Complete test reports may be required for any fitting selected at random.
2. Flanges shall have the manufacturer's trademark permanently identified in accordance with MSS SP-25.
3. Bolts used shall be carbon steel bolts with semi-finished hexagon nuts of American Standard Heavy dimensions. All-thread rods are not an acceptable substitute for flange bolts. Bolts shall have a tensile strength of 60,000 psi and an elastic limit of 30,000 psi.
4. All flanges shall have gaskets. Place gasket between flanges of flanged joints. Gaskets shall fit within the bolt circle on raised face flanges and shall be full face on flat face flanges.

H. Gaskets:

1. Gaskets shall be placed between the flanges of all flange joints. Such gaskets shall be ring form gaskets fitting within the bolt circle of their respective flanges.
2. All gaskets used on steam system shall be Flexitallic Style CG, AP1061 spiral wound 30455 with Grafoil fill as manufactured by Garlock or approved equal, regardless of pipe size and pressure.
3. The inside diameter of such gaskets shall conform to the nominal pipe size and the outside diameter shall be such that the gasket extends outward to the studs or bolts employed in the flanged joint.

2.02 PIPE

A. High Pressure Steam and Trapped Condensate Piping:

1. Pipe 2 inches and smaller: Carbon steel, ASTM A53, Grade B, seamless, Schedule 80.
 - a. Fittings: Forged steel, ASTM A105, socket weld, 300 lb.
 - b. Joints: Socket weld.
 - c. Unions: Forged steel, ASTM A105, socket weld, 3000 lb., stainless steel seats.
 - d. Gaskets: Flexitallic Style CG, API 601 spiral wound 304SS with Grafoil Fill or accepted substitution.
 - e. Cathodic Protection Gaskets: 1/16 inch thick Sealon by Ameriflex. Specify OD and ID of pipe and flanges. Bolt holes to be ¼ inch oversized.
2. Pipe 2-1/2 inches and larger: Carbon steel, ASTM A53, Grade B, seamless; standard weight for steam, Schedule 80 for condensate.
 - a. Fittings: Carbon steel, ASTM A234 WPB, seamless welding fittings, standard weight for steam, Schedule 80 for condensate.
 - b. Joints: Butt weld.

- c. Flanges: 300 lb., ANSI forged carbon steel, ASTM A181 Class 70, weld neck raised face.
 - d. Gaskets: Flexitallic Style CG, API 601 spiral wound 304SS with Grafoil Fill or accepted substitution.
 - e. Cathodic Protection Gaskets: 1/8 inch thick Sealon by Ameriflex. Specify OD and ID of pipe and flanges. Bolt holes to be ¼ inch oversized.
- B. Medium Pressure Steam and Trapped Condensate Piping:
- 1. Pipe 2 inches and smaller: Carbon steel, ASTM A53, Grade B, seamless, Schedule 80.
 - a. Fittings: 125 lb., cast iron, screwed, conforming to ANSI B16.4. Thread-o-lets may be used when the branch line is 1/3 the main size or less.
 - b. Joints: Screwed.
 - c. Unions: Class 300 malleable iron.
 - 2. Pipe 2-1/2 inches and larger: Carbon steel, ASTM A53, Grade B, seamless, standard weight for steam, Schedule 80 for condensate.
 - a. Fittings: ASTM A234, Grade WPB, ANSI B16.9; butt welding type, standard weight for steam, Schedule 80 for trapped condensate. Thread-o-lets may be used when the branch line is one-third the main size or less.
 - b. Joints: Butt weld.
 - c. Flanges: Class 150, ANSI B16.5, forged carbon steel, raised face. Materials in accord with ASTM A105, Grade II weld neck.
- C. Low Pressure Steam and Trapped Condensate Piping:
- 1. Pipe 2 inches and smaller: Carbon steel, ASTM A53, Grade B seamless, Schedule 40 for steam, Schedule 80 for condensate.
 - a. Fittings: 125 pound black cast iron. Thread-o-lets may be used when the branch line is one-third the main size or less.
 - b. Joints: Threaded.
 - c. Unions: Class 300 malleable iron.
 - 2. Pipe 2-1/2 inches and larger: Carbon steel, ASTM A53, Grade B, seamless, standard weight for steam, Schedule 80 for condensate.
 - a. Fittings: Butt weld, conforming to ASTM A234, Grade WPB, ANSI B16.9, standard weight for steam, Schedule 80 for trapped condensate.
 - b. Joints: Butt weld.
 - c. Flanges: Class 150, ANSI B16.5, forged steel, raised face. Materials in accord with ASTM A105, Grade II, weld neck.
- D. Condensate Piping (Building) – Return and Pumped Return:
- 1. All piping shall be extra strong black steel piping.

2. Fittings on piping 2-1/2 inches and larger shall be extra heavy butt welding type. Flanges shall be 150 lb. welding neck type. Extra strong Weld-o-lets, Thread-o-lets or shaped nipples may be used only when takeoff is one-third or less nominal size of main.
3. Screwed fittings around traps and for piping 2 inches and smaller shall be 125 lb. black cast iron (300 lb. for unions).

E. Condensate and Pumped Return Piping:

1. Pipe 2 inches and smaller: Carbon steel, ASTM A53, Grade B, seamless, Schedule 80.
 - a. Fittings: Forged steel, ASTM A105, socket weld.
 - b. Joints: Socket weld.
 - c. Flanges: 150 lb. ANSI forged carbon steel, ASTM A181, Class 70, socket weld with Flexitallic Style CG Gasket, API 601 spiral wound 304SS with Grafoil Fill or accepted substitution.
 - d. Cathodic Protection Gaskets: 1/8 inch thick Sealon by Ameriflex. Specify outside diameter (OD) and inside diameter (ID) of pipe and flanges. Bolt holes to be ¼ inch oversized.
2. Pipe 2-1/2 inches and larger: Carbon steel, ASTM A53, Grade B, seamless, Schedule 80.
 - a. Fittings: 150 lb. ANSI, forged carbon steel, ASTM A181, Class 70, weld neck.
 - b. Joints: Butt weld, beveled.
 - c. Flanges: 150 lb. ANSI, forged carbon steel, ASTM A 181, Class 70, weld neck with Flexitallic Style CG gasket, API 601 spiral wound 304SS with Grafoil Fill or accepted substitution.
 - d. Cathodic Protection Gaskets: Ameriflex. Specify OD and ID of pipe and flanges. Bolt holes to be ¼ inch oversized.

F. Low and Medium Pressure Clean Untreated Steam (304 Stainless Steel):

1. Pipe 2 inches and smaller: ASTM A312, TP 304, Schedule 40, seamless stainless steel.
 - a. Fittings: ASTM A182, Gr. F304, ANSI B16.11, 3000 lb. socket-weld.
 - b. Unions: 3000 lb socket-weld, stainless steel ground joint.
2. Pipe 2-1/2 inches and larger: ASTM A312, TP 304, Schedule 40, seamless stainless steel.
 - a. Fittings: ASTM A403, Gr. WP304/ANSI 16.9, Butt-weld.
 - b. Unions: None
 - c. Flanges: ASTM A182, Gr. F304, ANSI B16.5, 150 lb. standard with 1/16 inch raised face, serrated face finish and welding neck.
 - d. Bolts: Stud bolts, ASTM A193, Gr. B7.
 - e. Nuts: ASTM A194, Gr. 2H.

G. Equipment Drain Piping:

1. All factory fabricated or field erected steam equipment or apparatus that require drains shall be connected with adequately sloped drain line routed to a floor drain.
2. All drain piping shall be one-inch minimum diameter or larger as indicated on the Drawings or required by equipment. Such piping shall be standard weight galvanized steel pipe with galvanized malleable iron screw tees at each change in direction; or Type K, hard drawn copper tubing with threaded joints and fittings.
3. Install screw plug in unused openings for access to rod and clean.

2.03 VALVES

A. General:

1. All valves used in steam systems (low and medium pressure) shall be Class 150 SWP. Class 300 valves shall be constructed of all ASTM B-61 composition. All gate, globe and angle valves shall be union bonnet design. Metal used in the stems of all bronze gate, globe and angle valves shall conform to ASTM B371 Alloy 694, ASTM B99 Alloy 651 or other corrosion resistant equivalents. Written approval by the Owner must be secured for the use of alternative materials.
2. Manufacturers: NIBCO, Crane, Velan, Williams and Vogt.
3. All ductile Iron body valves shall have pressure containing parts constructed of ASTM A-395. Ductile iron stem material shall meet ASTM 371 Alloy 876 silicon bronze or its equivalent. Gates and globes shall be bolted bonnet with OS&Y (outside screw and yoke) and rising stem design.
4. All cast steel body valves shall have the pressure containing parts constructed of ASTM designation A-216-GR-WCB carbon steel. Gate and globe valves shall be bolted bonnet outside and screw and yoke design with pressure-temperature rating conforming to ANSI B16-34-1977. Stems shall meet ASTM designation A-186-F6 chromium stainless steel. Wedge (gate valves) may be solid or flexible type and shall meet ASTM A-182-F6 chromium stainless steel on valves from 2 inch to 6 inch. Sizes 8 inch and larger may be A-216-WCB with forged rings or overlay equal to 182-F6. Seat ring shall be hard faced carbon steel or 13 percent chromium A-182-F6 stainless. Handwheels shall be A47 Grade 35018 malleable iron or Ductile Iron ASTM A536.
5. All forged steel body valves shall have the pressure containing parts constructed of ASTM 105, Grade 2 forged carbon steel. Seat and wedges shall meet ASTM A-182-F6 chromium stainless steel. Seat rings shall be hard faced. Valves shall conform to ANSI B16-34 pressure-temperature rating.
6. All gate valves, globe valves, angle valves and shutoff valves of every character shall have malleable iron hand wheels, except iron body valves 2-1/2 inches and larger which may have either malleable iron or ASTM A-126 Class B, gray iron hand wheels.
7. Packing for all valves shall be free of asbestos fibers and selected for the pressure-temperature service of the valve. It is incumbent upon the manufacturer to select the best quality, standard packing for the intended valve service.
8. Valves 6 inches and larger located with stem in horizontal position shall be drilled and tapped in accordance with MSS-SP-45 to accommodate a drain valve and equalizing bypass valve assembly.

9. Valve Operator: Provide valve chain operator type on all shutoff valves shown on the Drawings that are 7'-6" above finished floor and higher. Chain operator shall be chain wheel of cast iron or malleable iron and designed to provide positive grip on wheel. Provide chain guide to prevent chain from slipping or jumping on wheel. Employ rust-proof chain complete with closing link of sufficient length to operate at 6'-6" above floor level.

B. Gate Valves:

1. High Pressure Steam and Trapped Condensate:
 - a. Socket Welded Pipe: 800 psig forged steel, welded bonnet, bolted gland, outside screw and yoke. Thread ends Vogt Ser. 2801 or socket weld Vogt 2801 SW.
 - b. Welded Pipe: Class 300 OS&Y, bolted flexible wedge disc. Crane Fig. No. 33 welded and flanged.
2. Medium and Low Pressure Steam and Trapped Condensate:
 - a. Threaded Pipe: 150 lb., screwed, bronze gate, rising stem, union bonnet, NIBCO T-134.
 - b. Welded Pipe: 150 lb. flanged OS&Y gate valve ductile iron, NIBCO F-637-31.
3. Building Condensate Return and Pumped Return:
 - a. Threaded Pipe: 150 lb., screwed, bronze gate, rising stem, union bonnet, NIBCO T-134.
 - b. Welded Pipe: 125 lb. flanged OS&Y gate valve ductile iron, NIBCO F-637-31.
4. Pumped Condensate Return:
 - a. Socket Welded Pipe: 800 lb. forged steel, socket weld, Vogt 2801 SW or threaded Vogt 2801.
 - b. Welded Pipe: 150 lb. carbon steel, butt welding ends (flanged ends where designated), OS&Y bolted bonnet, flexible wedge disc. Crane No. 47 ½ XU welded, 47 XU flanged.
5. Clean Steam:
 - a. Socket-welded Pipe: Stainless steel body, flanged, stainless steel solid wedge, stellite seats, rising stem, union bonnet, malleable iron handwheel impregnated Teflon packing, Class 150 (150 psi WP steam), Williams Figure S15F6-316.
 - b. Welded Pipe: Stainless steel body, flanged, stainless steel solid wedge, stellite seats, impregnated Teflon packing, Class 150 (150 psi WP steam), equal to Williams Figure S15F6-316.
 - c. Drain valves: Use gate valve as specified above with hose thread adapter. Provide ¾ inch minimum drain valve size except strainer blowdown valves to be blowdown connection size.

C. Globe Valves:

1. High Pressure Steam and Trapped Condensate:

- a. Manufacturers: NIBCO, Crane, Williams, Vogt, Velan.
 - b. Socket Welded Pipe: 800 psig forged steel, welded bonnet, bolted gland, outside screw and yoke. Thread ends Vogt Ser. 2821 or socket weld Vogt 2821 SW.
2. Medium Pressure Steam and Trapped Condensate:
 - a. Threaded Pipe: 200 lb., screwed, bronze globe valve, rising stem, with 500 Brinnell hardness plug disc and seat ring. NIBCO T-256-AP.
 - b. Welded Pipe: 150 lb. Flanged OS&Y globe valve ductile iron, NIBCO F-738-31.
3. Low Pressure Steam and Trapped Condensate:
 - a. Threaded Pipe: 200 lb., screwed, bronze globe valve, rising stem, with 500 Brinnell hardness plug disc and seat ring. NIBCO T-256-AP.
 - b. Welded Pipe 150 lb flanged OS&Y globe valve Ductile Iron NIBCO F-738-31.
4. Building Condensate Return and Pumped Return:
 - a. Threaded Pipe: 200 lb., screwed, bronze globe valve, rising stem, with 500 Brinnell hardness plug disc and sear ring. NIBCO T-256-AP.
 - b. Welded Pipe: 150 lb. flanges OS&Y globe valve Ductile Iron NIBCO F-738-31.
5. Clean Steam:
 - a. Socket-welded Pipe: Stainless steel body, flanged, stainless steel disc, stellite seats, impregnated teflon packing, union or screw-over bonnet, malleable iron handwheel Class 150 (150 psi WP steam), Williams Figure S152F6-316.
 - b. Welded Pipe: Stainless steel body, flanged, stainless steel disc, stellite seats, Class 150, (150 psi WP steam), Williams Figure S152F6-316 approved equivalent model by listed manufacturers.
- D. Check Valves:
1. High Pressure Steam and Trapped Condensate:
 - a. Socket Welded Pipe: 800 lb., forged steel, socket weld, stainless steel seat and disc, swing check. Crane No. 3682X or accepted substitution.
 - b. Welded Pipe: Class 300 carbon steel, bolted cover, weld end (flanged end where designated), stainless steel seat and disc, swing check, 147XU flanged.
 - c. Manufacturers: NIBCO, Crane, Williams, Velan, Vogt.
 2. Medium Pressure Steam and Trapped Condensate:
 - a. Threaded Pipe: 150 lb., screwed, horizontal swing check valve with screwed cap. NIBCO T-433-B.
 - b. Welded Pipe: 150 lb. flanged horizontal, swing check valve, ductile iron with bolted cap. NIBCO F938-31.
 3. Low Pressure Steam and Trapped Condensate, and Building Condensate Return, and Pumped Return:

- a. Threaded Pipe: 150 lb., screwed, horizontal swing check valve with screwed cap NIBCO T-433-B.
 - b. Welded Pipe: 150 lb. flanged horizontal, swing check valve, ductile iron with bolted cap. NIBCO F938-31.
4. TECO Pumped Condensate Return:
- a. Socket Welded Pipe: Class 600 steel body, stainless steel swing check. Crane 175-1/2XU.
 - b. Welded Pipe: Class 150 swing check, stainless steel trim. Crane 147-1/2 XU welded, Crane 147 flanged.
5. Clean Steam:
- a. Socket-welded Pipe: Stainless steel body, flanged, stainless steel disc, Class 150 (150 psi WP steam), Williams, Powell or Velan equal to Williams Figure S151F6-316.
 - b. Welded Pipe: Stainless steel body, flanged, stainless steel disc, Class 150 (150 psi WP steam), Williams Figure S151F6-316.
- E. Ball Valves:
1. Two-piece bronze body rated at 150 psi steam, TFE seats, stainless steel ball and stem. NIBCO T-585-70-66.
 2. The following manufacturers are acceptable if they comply with the specification: NIBCO, Apollo, or Watts.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly. All piping shall be clean when it is installed. Before installation it shall be checked, upended, swabbed if necessary, and all rust or dirt from storage or from lying on the ground shall be removed.
- C. Prepare piping connections to equipment with flanges or unions.
- D. After completion, fill, clean and treat systems.

3.02 WELDING OF STEAM SYSTEM PIPING

- A. Steam and condensate piping and fittings shall be welded and fabricated in accordance with the latest edition of ASME/ANSI the latest editions of Standards B31.9 for all systems. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.

- B. Ensure complete penetration of deposited metal with base metal. Provide filler metal suitable for use with base metal. Keep inside of fittings free from globules of weld metal. All welded pipe joints shall be made by the fusion welding process, employing a metallic arc or gas welding process. All pipe shall have the ends beveled 37-1/2 degrees and all joints shall be aligned true before welding. Except as specified otherwise, all changes in direction, intersection of lines, reduction in pipe size and the like shall be made with factory-fabricated welding fittings. Mitering of pipe to form elbows, notching of straight runs to form tees, or any similar construction is not permitted.
- C. Align piping and equipment so that no part is offset more than 1/16-inch. Set all fittings and joints square and true, and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.
- D. No weld shall project into the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.
- E. Remove all split, bent, flattened or otherwise damaged piping from the Project Site.
- F. Remove dirt, scale and other foreign matter from the inside of piping, by swabbing or flushing, prior to the connection of piping sections, fittings, valves or equipment.
- G. Schedule 40 pipe shall be welded with not less than three passes including one stringer/root, one filter and one lacer. Schedule 80 pipe shall be welded with not less than four passes including one stringer/root, two filler and one lacer. In all cases, however, the weld must be filled before the cap weld is added.

3.03 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Pipe Installation:
 - 1. Direct connection of a steam exhaust, blowoff or drip pipe shall not be made with the building drainage system. Discharge into the building drainage system shall be at a temperature not higher than 140 degrees F. When higher temperatures exist, approved cooling methods shall be provided.
 - 2. All the various piping systems shall be made up straight and true and routed in an orderly manner, plumb and parallel to the building structure. Install piping to conserve building space. Coordinate location with other trades and do not interfere with use of space for other work.
 - 3. Piping shall follow as closely as possible the routes shown on Drawings, which take into consideration conditions to be met at the Project Site.
 - 4. Should any unforeseen conditions arise, lines shall be changed or rerouted after proper approval has been obtained.
 - 5. All piping shall be installed with due regard to expansion and contraction and to prevent excessive strain and stress in the piping, in connections, or in equipment to which the lines are connected.
 - 6. Group piping whenever practical at common elevations.

7. Slope piping and arrange system to drain at low points. Use eccentric reducers to maintain bottom of pipe level.
8. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
9. Provide clearance for installation of insulation, and access to valves and fittings.
10. Prepare pipe, fittings, supports, and accessories for finish painting.
11. Procedure of Assembling Screw Pipe Fittings:
 - a. All screw joints shall be made with taper threads, properly cut.
 - b. Joints shall be made tight with Teflon-based compound appropriate to the medium, material, and temperature range of the system. Teflon tape is not permitted.
 - c. Compound shall be applied to the pipe threads only and not to fittings.
 - d. When threads are cut on pipes, the ends shall be carefully reamed to remove any burrs.
 - e. Before installing pipe that has been cut and threaded, lengths of pipe shall be upended and hammered to remove all shavings and foreign material.

D. Valve Installation:

1. Locate all valves such that the removal of their bonnets is possible. All flanged valves shown in horizontal lines with the valve stem in a horizontal position shall be positioned so the valve stem is inclined one bolt hole above the horizontal position. Screw pattern valves placed in horizontal lines shall be installed with their valve stems at a minimum 30 degree angle above the horizontal position. All valves must be true and straight at the time the system is tested and inspected for final acceptance. Install valves as nearly as possible to the locations indicated in the Drawings. Any change in valve location must be so indicated on the Record Drawings.
2. Equipment, valves, expansion joints, relief devices, strainers, etc., must be removed or isolated during the test if the pressure/force ratings of the devices are not as high as that specified for the test. Piping shall be drained and protected any time ambient temperature is below freezing.
3. Where leaks occur, the pipe shall be repaired and the tests repeated. No leaks shall be corrected by peening. Defective piping and joints shall be removed and replaced.
4. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with architectural drawings.
5. At the end of one year, period spot checks will be made and should the valve packing show signs of hardening or causing stem corrosion, all valves supplied by the manufacturer shall be repacked by the Contractor, at no expense to the Owner, with a packing material selected by the Owner.

3.04 CLEANING AND FLUSHING OF STEAM SYSTEMS

A. General:

1. Thoroughly clean steam and condensate systems before placing into operation to rid systems of rust, dirt, piping compound, mill scale, oil, grease, any and all other material foreign to water being circulated.
2. Exercise extreme care during construction to prevent dirt and other foreign matter from entering pipe or other parts of systems. Pipe stored on the project shall have open ends capped and equipment shall have openings fully protected. Before erection, each piece of pipe, fitting, or valve shall be visually examined and dirt removed.
3. Chemicals, feeding devices and water technician services shall be furnished by a single reputable manufacturer who will be responsible for the complete cleaning and flushing of the systems. Provide only chemical products that are acceptable under State and local pollution control regulations.
4. Add a temporary line with drain and isolate the building steam and condensate piping from the campus/building distribution piping to allow for proper circulation and cleaning of new piping in the new or modified building system.
5. Clean systems with a chemical compound specifically formulated for the purpose of removing the above listed foreign matter. These chemicals shall be injected to the systems, circulated and completely flushed out. Repeat the process if required. After each flushing, remove and thoroughly clean all strainers. UH representative shall be present for flushing process.
6. Final connection shall not be made to the campus/building loop system until the Chemical Contractor has filed with the Owner's representatives, a report stating that the systems are clean.

B. UH Systems:

1. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the systems in service. Provide whatever temporary connections are required for cleaning, purging and circulating.
2. Install temporary strainers in front of pumps, tanks, water still, solenoid valves, control valves and other equipment where permanent strainers are not indicated. Where permanent strainers are indicated, assure that the strainers are installed and screens are in place and are cleaned. Keep temporary strainers in service until the equipment has been tested, then replace straining element with a new strainer and clean and deliver the old straining elements to Owner. Fit strainers with a line size blow-off valve.
3. Circulate a chemical cleaner in steam and condensate piping system to remove mill scale, grease, oil and silt. Circulate chemical cleaner for 48 hours, flush system and replace with clean water. Dispose of chemical solution in accordance with local codes. When the chemical cleaning is complete, remove, clean and reinstall all permanent screens. Notify Owner so that the reinstallation of clean strainer screens may be witnessed.

3.05 TESTING

A. Weldings:

1. All welds are subject to inspection, visual and/or x-ray, for compliance with Specifications. The Owner will, at the Owner's option, provide employees or employ a testing laboratory for the purposes of performing said inspections and/or x-ray testing. Initial visual and x-ray inspections will be provided by the Owner. Contractor shall be responsible for all labor, material and travel expenses involved in the re-inspection and retesting of any welds found to be unacceptable. In addition, Contractor shall be responsible for the costs involved in any and all additional testing required or recommended by ASME/ANSI Standards B31.9 and B31.3 due to the discovery of poor, unacceptable or rejected welds.
2. Welds lacking penetration, containing excessive porosity or cracks, or are found to be unacceptable for any reason, must be removed and replaced with an original quality weld as specified herein. All qualifying tests, welding and stress relieving procedures shall, moreover, be in accord with Standard Qualification for Welding Procedures, Welders and Welding Operators, Appendix A, Section 6 of the Code, current edition.

B. Pipe Pressure:

1. Equipment, valves, vents, expansion joints, pressure reducing stations, etc., must be removed or isolated from test pressure and/or forces if the devices are not rated for the test pressures. All water must be drained from all steam system piping and devices after test completion. Piping shall be drained and protected any time the ambient is below freezing.
2. The following lines shall be tested at the stated pressure for the length of time noted:

Line	Testing Medium	Testing Pressure (psig)	Time in Hours
Steam M.P. & L.P.	Water	150	24
Steam Condensate M.P.	Water	150	24
Steam Condensate H.P. Pumped	Water	150	24
Condensate Return			

3. Where leaks occur, repair pipe and repeat tests. No leaks shall be corrected by peening. Remove and replace defective piping and joints.
4. Condensate Return to Power Plant:
 - a. Dump condensate until acceptable to UH Power Plant. Fifteen (15) micromhos or less conductivity for the TECO Main Central Plant and 200 micromhos or less conductivity for the Power Plant. UH will test condensate samples and will notify Contractor when condensate is acceptable to return.
 - b. Each time the steam system is cycled, the condensate must again be tested.
 - c. After the above requirements have been met, the building will be scheduled to have steam services turned on.
 - d. Unnecessary cycling or intermittent use of thermal systems will not be permitted.

END OF SECTION 23 22 13

SECTION 23 22 30 – STEAM AND STEAM CONDENSATE SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install the following steam specialties indicated by the Contract Documents with supplementary items necessary for their proper installation.
 - 1. Steam traps.
 - 2. Flash tanks.
 - 3. Condensate return pumping units.
 - 4. Steam pressure-reducing valves.
 - 5. Steam relief valves.
 - 6. Steam safety valve discharge elbows.
 - 7. Steam muffler attachments.
 - 8. Steam pipe anchors.
 - 9. Steam pipe guides.
 - 10. Drip traps.
 - 11. Sediment strainers.
 - 12. Automatic air vents.
 - 13. Gauges and gauge connections.
 - 14. Thermometer and thermometer wells.
 - 15. Steam orifice meters.
 - 16. Steam integrating (condensate) meters.
 - 17. Steam vortex meters

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. ASTM A105 - Forgings, Carbon Steel, for Piping Components.
 - 2. ASTM A216 - Steel Casings, Carbon, Suitable for Fusion Welding, for High Temperature Service.
 - 3. ASTM A395 - Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
 - 4. ASME B31.9 - Building Services Piping.

1.04 QUALITY ASSURANCE

- A. All specialties of the same type shall be provided from the same manufacturer.
- B. Manufacturer's name and pressure rating marked on body of each device.

1.05 SUBMITTALS

- A. Product Data:
 - 1. Submit Shop Drawings, wiring diagrams and product data on all steam specialties.
- B. Record Documents:
 - 1. Shop Drawing submittal of traps shall contain an itemized list with a tabulation of the load, trap type and trap size.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. Steam Traps:
 - 1. Armstrong.
 - 2. Spirax Sarco.
 - 3. Spence.
- B. Flash Tanks:
 - 1. Penn Separator.
 - 2. Wendland.
 - 3. Wilson.
- C. Condensate Pumping Units:
 - 1. Skidmore.

2. Aurora.
 3. Mepco.
 4. Spirax Sarco
- D. Pressure Powered Condensate Pumps:
1. Armstrong.
 2. Spriax Sarco.
 3. Spence
- E. Steam Pressure Reducing Valves:
1. Leslie.
 2. Spence.
 3. Spirax Sarco.
 4. Fisher.
- F. Steam Relief Valves:
1. Consolidated Type 1511.
 2. Spirax Sarco 211S or SV Series.
 3. Spence Engineering 41.
 4. Crane 2501.
- G. Steam Discharge Pan Elbows:
1. Grinnell Fig. No. 1538F.
 2. Spirax Sarco DPE.
 3. Spence Engineering DPE.
- H. Steam Muffler Attachment:
1. Consolidated Type 1441.
 2. Wright Austin 40EHC.
- I. Automatic Air Vents:
1. Spirax Sarco 13W
 2. Spence Engineering.
- J. Sediment Strainers:
1. Muller Steam Specialty.
 2. Keckley.

3. Spirax Sarco

K. Gauges:

1. Ashcroft No. 1279-R Duragauge.

L. Thermometer and Wells:

1. Weksler Industrial Thermometers.
2. Ashcroft 1279-R.
3. Conbraco 20-150.

M. Steam Orifice Meters

1. [No selections]

N. Steam Condensate Integrating Meters:

1. Daniel Model CRA turbine meter.
2. Winters.

O. Steam Vortex Flow Meters

1. Onicon F-2000/2500 Series Vortex Flow Meter (Basis of Design) or approved equal.

P. Vacuum Breakers:

1. Spirax Sarco VB
2. Kadent Johnson VB

2.03 INVERTED BUCKET TRAPS

- A. Cast iron or semi-steel body and bolted cover for 250 psig working steam pressure (WSP); provide access to internal parts without disturbing piping; with top test plug and bottom drain plugs, brass or stainless steel bucket, stainless steel seats and plungers, and stainless steel lever mechanism with knife edge operating surfaces.

2.04 FLOAT AND THERMOSTATIC TRAPS

- A. ASTM A126, cast iron or semi-steel body and bolted cover for 125 psig WSP; provide access to internal parts without disturbing piping; with bottom drain plug, stainless steel or bronze bellows type air vent, stainless steel or copper float, stainless steel lever and valve assembly.
- B. Float and thermostatic traps for clean steam service shall have Type 316L stainless steel bodies, covers, and all internal components.

2.05 THERMOSTATIC TRAPS

- A. Pressure balanced type with ASTM A216 WCB cast steel body and bolted or screwed cover and integral ball joint union, for 300 psig WSP; monel or stainless steel bellows, stainless steel valve and seat; integral stainless steel strainer.

- B. Freeze-proof type with cast iron body for 300 psig WSP, bronze bellows, stainless steel valve and seat, external adjustment.
- C. Bi-metallic type with ASTM A105 forged steel body and cover, for 300 psig WSP, bi-metal element with stainless steel components, integral Type 304 stainless steel strainer screen, and ¼ inch blow down valve.
- D. Clean steam thermostatic traps for non-critical process areas shall be self-adjusting balanced pressure type capable of operating close to saturated steam temperature. All wetted parts shall be manufactured from Type 316L stainless steel. Traps shall be maintainable, of sealed construction, and shall be completely self-draining when installed in vertical pipeline.

2.06 FLASH TANKS

- A. Closed type, welded steel construction, tested and stamped in accordance with Section 8D of ANSI/ASME Boilers and Pressure Vessels Code for 125 psig working pressure; cleaned, prime coated and supplied with steel support legs. Construct with nozzles and tappings for installation of accessories and piping connections.

2.07 CONDENSATE PUMPING UNITS

- A. Condensate pumping units shall be duplex horizontal type to include receiver, interstrainer, duplex pumps, float switches, control panel and accessories. Pumps shall be single-stage centrifugal type with head capabilities and flow rates as scheduled. Pumps shall be capable of pumping 212 degrees F condensate at the controlled water level.
- B. Unit shall be complete with 3/16 inch thick steel receiver with rust resistant coating and shall have magnesium anode protection.
- C. Each motor shall be provided with safety switch and a magnetic starter with current overload relays providing overload and undervoltage protection. These magnetic starters shall be provided with three-pole overload protection.
- D. Pumps shall be bronze fitted throughout. Bearings shall be such as to protect them from dust and corrosion.
- E. Each unit shall have fully automatic control by a float and float switch. An alternator switch shall be provided as a part of the unit to automatically alternate pumps at the end of each pump operation.
- F. All accessories and auxiliaries, such as pressure gauges, water gauge glasses, etc., shall be installed complete.
- G. Electrical wiring and controls shall be complete so that no wiring beyond that required by the driving motor need be supplied in the field. Such units shall be tested at the factory and adjusted prior to shipment. Alternator shall be mechanical type. If electrical alternator is used, it shall be Allen Bradley.
- H. Each pump shall have stainless steel shafts. Furnish an extra set of Viton seals. Each duplex pump shall have two-point power connections (not a single point) and integral shut-off valves upstream and downstream of each pump.
- I. Capacities and electrical characteristics shall be as scheduled on Drawings.
- J. Provide high level alarm switch complete with transformer, bell and one set of 120 volt AC rated, normally open contacts for connection to the building automation system (BAS).

- K. Control Cabinet: NEMA II enclosure, UL listed, with piano hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, electric alternator, AUTO-OFF switch, test button, terminal strip, high level alarm light, acknowledge button, alarm horn and fusible control circuit transformer. Provide a normally open auxiliary alarm contact for connection to the BAS.

2.08 PRESSURE POWERED CONDENSATE PUMPS (PUMPING TRAP)

- A. Pressure powered condensate pump (pumping trap) operated by steam, compressed air, or other pressurized gas, which does not require any electrical energy, and is safe for use in explosive atmospheres. Spring assisted float mechanism with no external seals or packing.
- B. Stainless steel float and operating mechanism, inconel or stainless steel springs, and stainless steel trim.
- C. Cast iron or fabricated steel bodies shall be S150 psi ASME rated and steel bodies shall be stamped.
- D. Provide with factory-attached stainless steel swing type check valves on inlet. and stainless steel spring type check, Durable type SCV, on discharge.

2.09 STEAM PRESSURE REDUCING VALVES

- A. All pressure reducing valves shall be capable of maintaining the set pressure from zero to the maximum steam flow within reasonable limits when subjected to steam pressure fluctuations.
- B. Valve bodies shall be cast steel for high-pressure service and cast iron for medium and low-pressure service. Stations having a total steam capacity less than 3000 pounds per hour shall consist of one PRV with a minimum rangeability of 20:1. Discharge pressure shall be adjustable to any value between 10 percent and 75 percent of the supply pressure. Stations having a total steam capacity greater than 3000 pounds per hour shall consist of two PRV's sized with a 1/3, 2/3 or 50 – 50 percent capacity split as indicated by the Drawings, and each capable of a minimum control rangeability of 20:1.
- C. High-pressure PRV's shall be pneumatically actuated rotary control valves. The valve bodies shall be cast carbon steel with integral 300-pound ANSI flanged ends. Valve plug design shall be eccentric rotary action offset to the shaft centerline. Seat ring shall be available in full port as well as 60 percent, 40 percent and 20 percent reduced port. Plug and seat ring shall be 316 stainless steel with satellite overlay. Stem packing shall be carbon graphite. Valve actuators shall be suitable for 60 psi control air and shall be selected to provide tight shut-off without air assist. Each actuator shall be provided with an electro-pneumatic valve positioner with gauges, control air regulator and 3-way 120VAC solenoid valve. The positioner, air regulator and 3-way solenoid valve shall be factory installed and connected with 3/8 inch outside diameter (OD) stainless steel tubing. The 3-way solenoid valve shall be rated for continuous duty and shall be connected to vent on loss of power.
- D. When necessary to achieve required noise attenuation, high-pressure PRV's shall be provided with silencing orifice plates for noise attenuation. The high-pressure valves and orifice plates shall be sized and selected so as to minimize noise generation, including pipe insulation, to 85 dBA or less at three (3) feet from the valve. The silencing orifice shall be of 300 series stainless steel and shall be designed to install between two 300-pound ANSI flanges in the expanded section of pipe downstream of the PRV.

- E. Each high-pressure PRV station shall be supplied with an electronic pressure controller and pressure transducer. The pressure transducer shall be mounted with a block valve and coil siphon in the common downstream header of the PRV station, and shall be wired by the BAS Provider back to the electronic pressure controller with shielded cable. The electronic controller shall be mounted in a NEMA 4X fiberglass enclosure. The enclosure shall include a 120 VAC circuit breaker, 24 VDC power supply and all other control relays necessary to provide the control requirements. The electronic controller shall provide a 4-20mA signal to the electro-pneumatic valve positioner(s) to modulate the control valves to maintain the system pressure. The controller shall be configured to accept a 4-20mA input for remote set point. The controller enclosure shall provide 120VAC to the 3-way solenoid valve(s). The controller shall have a high pressure limit that will interrupt the control signal to the valve(s) and de-energize the 3-way solenoid valve(s). Provide a normally open auxiliary high pressure alarm contact for connection to the BAS. Provide terminal points for all connections.
- F. Medium and low-pressure PRVs shall be single-seated, pilot-operated valves with 250-pound cast iron bodies, stainless steel trim with renewable valve plugs and seats.
- G. All pressure regulators 2-½ inches and larger shall have flanged connections. Pressure regulators 2 inches and smaller may have screwed connections. Unions shall be installed on each side of any screwed pattern regulators installed.
- H. Each reducing valve shall be preceded by a sediment strainer complete with a full-sized blowoff valve with threaded end for hose connection.

2.10 STEAM RELIEF VALVES

- A. Relief valves 2 inches and smaller shall have brass bodies and arranged for screwed connections. Such relief valves shall be Spence Type 41 or Spirax Sarco 211 Series safety valves for steam. Bushings shall not be used.
- B. Relief valves 2-1/2 inches and larger for all medium and low pressure steam piping systems be arranged for flanged inlet and screwed outlet connections. Such relief valves shall be Spence Type 41 or Spirax Sarco SV Series, ASME Standard Cast Iron Safety Valves.
- C. The pressure at which each relief valve shall open is designated on the Drawings. Specify the pressure at which each relief valve must be set. Each valve shall have a metal tag attached stamped with the valve identification plus the pressure setting. Each valve shall be sized at full steam flow through the PRV and discharge piping must be equal or greater than the steam relief valve outlet size.
- D. Safety relief valve shall comply with ASME Section 1 or 8 as applicable. Provide Certificate of Conformance per ASME standard.

2.11 DRIP TRAPS

- A. Traps shall be 3/4 inch traps unless specifically shown to the contrary, i.e., they shall have 3/4 inch inlet and outlet connections.
- B. High-pressure drip traps shall have steel or semi-steel bodies and the internal operating mechanisms shall be made of heat-treated chrome steel. The caps shall be bolted to the bodies by the use of alloy steel heat-treated machine bolts, No. 300 Armstrong Traps, manufactured by Armstrong Machine Works. Capacity for discharging at least 3,500 pounds of condensate per hour when operating at a pressure of 250 pounds per square inch.
- C. All drip traps used in medium pressure steam piping systems shall be 3/4 inch Armstrong No. 811 inverted bucket traps, with cast iron bodies and stainless steel trim.

- D. Low-pressure traps shall be equal to Armstrong "A" or "B" series sized to handle 200 percent of the load with an operating differential pressure equal to 50 percent of the inlet steam pressure.

2.12 SEDIMENT STRAINERS

- A. Sediment strainers in high pressure steam piping shall be cast steel and shall be suitable for working steam pressures as high as 300 pounds per square inch and temperatures not in excess of 750 degrees F.
- B. For pipe sizes 2-1/2 inches and larger, flanged pattern sediment strainers shall be used. For pipe smaller than 2-1/2 inches, screwed pattern shall be used.
- C. The flanges of flanged strainers shall be dimensioned, faced, drilled and spot faced to conform to the 300-pound American Standard for Steel Pipe Flanges and Flanged Fittings (B16E-1939).
- D. Strainers in low and medium pressure steam piping systems 2-1/2 inches and larger shall be flanged iron body strainers having bolted covers. These strainers shall be suitable for operating pressures as high as 125 psig.
- E. Sediment strainers in low and medium pressure steam piping systems 2 inches and smaller shall be arranged for screwed pipe connections.

2.13 GAUGES AND GAUGE CONNECTIONS

- A. Pressure gauges for interior steam systems shall be 4-1/2 inches with back connection when used on a panel; otherwise they shall have bottom connections. Each gauge shall be provided with Ashcroft carbon steel needle valve and a siphon rated for the steam pressure and temperature. The arrangement of the mechanisms shall conform to pressure ranges and details shown on the Drawings.
- B. The dial graduation shall be 1.5 times the highest working pressure of the steam that the gauge is serving.

2.14 THERMOMETER AND THERMOMETER WELLS

- A. Furnish and install thermometers of not less than 9 inch scale complete with brass separable sockets with extension neck to allow for insulation of piping. These thermometers shall be mercury red reading type in one piece glass tubes extending from top of scale to sensor, and shall be located so that they may be easily read. Field adjustable angle thermometers are acceptable.
- B. Thermometers shall be provided with range of 0 to 220 degrees F at hot water heat exchangers. The sensing element of the thermometer shall be at least one inch into the pipe.
- C. Thermometer test wells shall be 3/4 inch Weksler thermal wells, brass with stem of minimum length to extend beyond the mid-diameter of the pipe, 2-1/2 inch extension neck and brass screw plug. Wells shall be suitable for use of industrial type thermometers.
- D. Indicating thermometers shall be Weksler industrial thermometers having stainless steel separable sockets and scales of the range suitable for steam pressures indicated on flow sheets.

2.15 STEAM CONDENSATE INTEGRATING METERS

- A. Furnish and install turbine meter in the condensate return system as indicated on Drawings. Turbine meter to be installed to read GPM from all pumps.

- B. Meter shall be constructed of stainless steel with stainless steel internal parts and tungsten carbide bearings:
 - 1. Maximum Operating Range: 210 degrees F.
 - 2. Pressure Range: 0 to 100 psig.
 - 3. Maximum pressure drop: 4 psig.
 - 4. Condensate Flow Rate: Engineer shall complete.
 - 5. Output: 12 VDC.
 - 6. Maximum Accuracy \pm 0.05 percent over linear flow range.
 - 7. Power Available: 12 VDC.

2.16 FINNED TUBE RADIATION

- A. General: Supply and install finned tube radiation of the type, length and dimensions as shown on the Contract Documents. Finned tube radiation shall be the product of Engineered Air. All finned tube radiation components shall be cleaned and phosphatized to prevent corrosion. They shall be finished with a baked cactus gray enamel primer.
- B. Copper-Aluminum Element: Tubing shall be 1- $\frac{1}{4}$ inch nominal ID (1- $\frac{3}{8}$ inch OD) seamless copper. Fins shall be aluminum, 4- $\frac{1}{4}$ inch x 4 inch, 0.015-inch thick with a stamped pattern for strength and rigidity. Fins shall have integral collars to provide even spacing and maximum heat transfer. Fins shall be firmly bonded to the tube by mechanical expansion. All copper-aluminum elements shall have 50 fins/foot. Tube ends shall be suitable for connecting with sweat fittings.
- C. Element Brackets: Element brackets shall consist of a steel cradle mounted on a roller bearing, which will allow free and quiet element expansion. Element brackets shall be securely fastened to wall brackets or wall, on not more than 4-foot centers.
- D. Dampers: Dampers shall be knob operated and have a screw-type control with a channel-type damper blade located behind the outlet grille. Damper mechanism shall provide complete adjustment between fully opened and fully closed positions.
- E. Access Doors: Provide access doors where shown on Drawings. They shall consist of a surface-mounted 7 inch x 7 inch frame with a 6 inch x 6 inch continuous hinged door fitted with a slot operated cam lock. Flush-mounted factory-installed access doors are also acceptable.
- F. Protective Covers: $\frac{1}{2}$ -inch diamond mesh, 18-gage expanded steel cover (Type WF-7) shall be provided. Covers should not contact element and shall be supported by combination bracket.

2.17 VACUUM BREAKERS

- A. Vacuum breakers shall be used on all modulating or on/off heat exchangers and coils, except in vacuum return systems.
- B. Vacuum breakers shall be of hardened ball check valve design with all working parts manufactured from stainless steel.

- C. Bodies shall be made of brass or stainless steel and shall be suitable for operating conditions of 300 psig saturated steam.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. Install specialties in accordance with manufacturer's instructions.
- C. Install float and thermostatic traps to drain condensate from unit heaters, converters, heating coils, steam separators, flash tanks, steam jacketed equipment and direct steam injected equipment.
- D. Install inverted bucket steam traps to drain condensate from steam main headers and branch lines at an operating differential pressure equal to 50 percent of the inlet steam pressure unless noted otherwise.
- E. Install thermostatic steam traps to drain condensate from steam radiation units, converters, and other similar terminal heating units.
- F. Size steam traps to handle minimum of two times maximum condensate load of apparatus served.
- G. Traps used on steam mains and branches shall be minimum 3/4-inch (20 mm) size.
- H. Install steam traps with union or flanged connections at both ends.
- I. Provide gate valve and strainer at inlet and gate valve at discharge of steam traps.
- J. Provide minimum 10-inch (250 mm) long dirt pocket of same pipe sizes as apparatus return connection between apparatus and steam trap.
- K. Remove thermostatic elements from steam traps or valve out during temporary and trial usage and until system has been operated and dirt pockets cleaned of sediment and scale.
- L. Provide pressure-reducing stations with pressure reducing valve, valved bypass, strainer and pressure gauge on upstream side, relief valve and pressure gauge on downstream side of pressure reducing valve.
- M. Pressure reducing station shall be [one] [two] stage to produce flat reduced pressure curve over range of capacity.
- N. Rate relief valves for pressure upstream of pressure reducing station, for full operating capacity. Set relief at maximum 20 percent above reduced pressure.
- O. Terminate relief valves to outdoors. Provide drip pan elbow with drain connection to nearest floor drain.
- P. When several relief valve vents are connected to a common header, header cross sectional area shall equal sum of individual vent outlet areas.
- Q. Steam Safety Valve Discharge Elbows:

1. All vent lines from safety valves shall be provided with safety valve discharge elbows at the point at which such lines rise to an elevation higher than that of the safety valve. The nature and design of the piping systems involved shall effectively drain all condensate from the discharge side of all relief valves. No force shall be exerted on the safety valve by the discharge piping.

R. Steam Muffler Attachments:

1. At the point at which vent lines from safety valve discharge elbows terminate, a muffler attachment of the proper size shall be installed.
2. These muffler attachments shall be screwed pattern members.

S. Steam Pipe Anchors:

1. All steam lines shall be securely anchored at points designated on the Drawings and/or at such points as may be needed to assure proper control of the expansion and contraction of such systems.

T. Steam Pipe Guides:

1. All steam piping systems shall be properly guided.

U. Drip Traps:

1. High-pressure drip trap assemblies shall be provided per the Contract Documents and where required to keep piping systems completely drained of condensate.
2. Where drip taps are installed in conjunction with 3 inch and larger steam lines, a drip pocket of the nature detailed on the Drawings shall be provided where a natural pocket does not exist. The piping and valves in trap assemblies shall be arranged as detailed on the Drawings; extra strong pipes shall be used on both sides of the trap. The diameter of the drip pocket shall be the same size as the distribution line up to 4 inches in diameter. The diameter shall be half the size of the distribution line over 4 inches but never less than 4 inches.
3. All drip traps used in medium pressure steam piping systems where automatic steam control valves are not employed shall be arranged as shown on the Drawings. Each trap shall be provided with a valved test line and shall be preceded by a sediment strainer.
4. Condensate traps from coils, convertors, hot water generators, and all other devices where modulating steam valves are employed shall be of the float and thermostatic type. Installed traps with less than 12 inch of height between equipment outlet and trap inlet shall be sized for not less than 300 percent of the load. Each trap shall be provide with a ½ inch valve test line and shall be preceded by a sediment strainer. A vacuum breaker shall be supplied for these applications and it can be integral to the trap. Under no circumstances shall a float and thermostatic trap be installed in a manner to lift condensate up in a return line.

V. Sediment Strainers:

1. Each drip trap assembly, each control valve, for steam and each pressure reducing valve assembly regardless of its size shall be preceded by a sediment strainer. The arrangement of these sediment strainers shall be such that the screens may be removed for cleaning with ease through a gasketed plug.

2. Sediment strainers shall be placed in steam piping systems wherever shown on the Drawings and at such other points as may be required for the removal of foreign material from the piping systems.
3. Full sized blow off valves shall be installed on all strainers in steam, condensate, chilled and hot water lines and a drain shall be installed from each valve to the nearest floor drain.

W. Automatic Air Vents:

1. Provide auto air vents with a pressure rating that is equal to system classification but not less than 125 psig. Provide shut-off valve to facilitate maintenance of air vent.
2. Locate all air vents and their discharge lines in accessible locations, preferably clustered.

X. Thermometer and Thermometer Wells:

1. Thermometers shall in all cases be installed upright or at the proper angle to be read while standing on the floor. The wells for thermometers shall be located in vertical pipes where possible. When installed in horizontal pipes, thermometers shall be installed in the side and not on top of the pipe.
2. Thermometer wells and thermometers shall be located where noted on the Drawings and where called for in other Specification Sections. Thermometer test wells shall only be installed in a vertical position in horizontal lines and at 45 degrees in vertical lines to hold a fluid in the well.

Y. Condensate Integrating Meters:

1. Meters shall be mounted in a horizontal position at the pump discharge with required upstream and downstream straight runs of pipe.
2. Furnish and install a line size spool piece in the main until all piping has been cleaned and flushed.

Z. Condensate Pumping:

1. Install condensate pumping units on a housekeeping pad.
2. Install vent and overflow piping as detailed in the Drawings. Route the overflow pipe to a floor drain. Provide and pipe a receiver drain valve and pipe to the nearest floor drain.
3. Install spring assisted check valves in the discharge of each pump. Install globe valves for pump balancing in the discharge of each pump. Install gate valves downstream of the globe valves.
4. Pump discharge lines 1-1/2 inches and larger shall be piped to the condensate return piping with stainless steel flex connectors.

AA. Pressure Powered Condensate Pumps (Pumping Trap):

1. Do not install pumping traps on housekeeping pads (housekeeping pads reduce the filling head to the pump). Install the pump at the lowest possible point below the equipment that is being drained.

2. Where specified, provide an inlet condensate receiver. The receiver shall be an ASME vessel as shown on the Drawings. Install and support the receiver above the pumping trap unit. Route all condensate to be drain to the top on the receiver. The receiver shall be vented to atmosphere and shall also be supplied with a drain connection and drain valve.
3. The pumping trap body shall be provided with a gauge glass assembly.
4. When motive gas pressure is greater than 20 psig over the required discharge head, provide a PRV assembly to regulate motive gas pressure. The PRV assembly shall include an inlet block valve, y-strainer, PRV and pressure gauge assembly. When motive gas is steam, install a drip trap assembly upstream of the PRV. When motive gas is air or nitrogen, provide a spring loaded check valve downstream of the PRV.
5. Route the exhaust vent pipe of the pumping trap, and the receiver vent (when receiver is installed), to an atmospheric vent line, or, it may be routed 8 to 10 feet up and piped back down a minimum of 6 inches. Install a drain valve and drain line off the pumping trap unit and route to the nearest floor drain.

BB. Vacuum Breakers:

1. Vacuum breakers shall be installed in the supply side between the control valve and equipment.
2. Install in a vertical position with cap at top.
3. Mount the vacuum breaker on the highest point of the circuit.
4. Large coils or equipment may require more than one vacuum breaker to be fitted.

END OF SECTION 23 22 30

SECTION 23 25 00 - WATER TREATMENT SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Perform water analysis and provide water treatment products, holding reservoirs, equipment, and labor for testing, cleaning, flushing, and dispensing products to control water quality for each system specified as follows:
 - 1. Chilled water system.
 - 2. Heating water system.
 - 3. Condenser water system.
 - 4. Steam boiler feedwater system.
 - 5. Glycol system.
- B. Chemicals: Provide, at no change in Contract amount, chemicals required for operating and testing water treatment systems prior to acceptance by the Owner.
- C. Instructions: Provide operation and maintenance instructions for each water treatment system; include one set in each Owner's Manual and deliver one set to Owner's operating personnel.
- D. Testing Equipment and Reagents: Furnish suitable water treatment testing equipment for each system, complete with apparatus and reagents necessary for operation until acceptance by the Owner.
- E. Service Representative: Furnish the services of a qualified service representative to instruct Owner's operating personnel in proper operation and maintenance of water treatment equipment, systems, and tests required. Service representative shall return to the site biweekly during first 2 months of operation and monthly during the remainder of the guarantee period. At such times, service representative shall check and adjust water treatment system operation, check efficiency of chemicals and chemical applications, and instruct and advise operating personnel.
- F. Replacement and Rework: Replace defective or nonconforming materials and equipment with new materials and equipment, at no change in Contract amount, for one year after successful start-up of the system. All warranty work shall be FOB as installed at the project site.
 - 1. Guarantee: Provide system by manufacturer willing to execute the required guarantee.
 - 2. Agreement to Maintain: Provide system by manufacturer willing to execute (with the Owner) the required agreement for continued maintenance of the system.

1.3 QUALITY ASSURANCE:

- A. Qualifications: To perform work under this Section, the Contractor shall have:
 - 1. Research and development facilities.
 - 2. Regional laboratories capable of making water analysis.
 - 3. A service department and qualified technical service representatives located within a reasonable distance of the project site.
 - 4. Service representatives who are Registered Engineers or factory-certified technicians with not less than 5 years of water treatment experience with the water treatment system manufacturer.

[SELECT ONE OF THE FOLLOWING]

- B. **Manufacturers: Provide water treatment chemicals and products manufactured by one of the following:**
 - 1. **DuBois.**
 - 2. **Mitco.**

3. **Mogul.**
4. **Morr.**
5. **Nalco.**
6. **Uniloc.]**

[OR]

- C. **[Manufacturers: Vendor for water treatment chemicals and treatment shall be [Nalco] [] to insure compatibility with the existing water systems which are being extended under this project.]**
- D. Chemicals: Chemicals shall meet all requirements of federal, state and local pollution requirements and all other applicable laws and governing regulations. In addition, all chemicals shall be fully compatible with all components and parts of the particular system being treated. All chemical containers and labeling shall be in accordance with applicable regulations.
- E. Packaging and Labeling: Supply water treatment chemicals in metal drums, fiber drums with plastic liners, or plastic lined "liqui-paks" as best suited to the materials. Paper bags or unlined cardboard cartons will not be acceptable. Chemicals in domestic water systems, and biocides, regardless of where used, shall be registered with the U.S. Department of Agriculture (USDA) or the U.S. Environmental Protection Agency (EPA) and labeled as required by law.
- F. Electrical Standards: Provide electrical products which have been tested, listed, and labeled by Underwriters' Laboratories, Inc. (UL) and comply with National Electrical Manufacturers' Association (NEMA) standards.
- G. Chemical Standards: Provide chemical products acceptable under state and local pollution control or other governing regulations.

1.4 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
 1. A water analysis, including the name and address of the company performing the analysis.
 2. Cut sheets on all proposed chemical treatments [and a statement of compatibility with existing treatment chemicals and systems].
 3. A list of proposed chemicals and their application.
 4. Cut sheets on all water treatment system components and accessories which are being furnished and control panel elevations.
 5. Installation details for water treatment system components including, but not limited to: wiring diagrams, piping diagrams, injector coupling installation details and other information required for proper system installation.
 6. Submit written guarantee, signed by the manufacturer and countersigned by the installer and Contractor, agreeing to adjust or replace the system or portions thereof, as required to achieve the required performance, during a one year period following the final start-up for continued operation.
 7. Additional information as required in Section 23 01 00.
- B. Agreement to Maintain: Prior to final acceptance, the manufacturer of the condenser water treating system shall submit four copies, to the Owner's for possible acceptance, of an "Agreement for Continued Service" to furnish chemicals and provide continued testing and servicing, including replacement of materials and equipment, for a one year period with option for renewal of the Agreement by the Owner.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver water treatment products in factory-fabricated water-resistant wrapping.
- B. Handle water treatment products carefully to avoid damage to material component, enclosure and finish.

- C. Store water treatment products in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. Water Analysis: Determine which chemicals to use from the results of a water sample analysis per ASTM D596 on a water sample taken from the building site by the system manufacturer. Provide ingredients necessary to achieve the desired water conditions.
- B. Boilout Chemicals: Use chemicals for boilout as recommended by the boiler manufacturer for removing internal coatings and preservatives added during the manufacturing process. Chemicals shall be equal to Nalco No. 2567 boilout compound.
- C. Pretreatment: Treat each piping system with chemicals to remove and permit flushing of mill scale, oil, grease, and other foreign matter. Chemicals shall be equal to Nalco No. 2569 prepping compound [and shall be compatible with existing water treatment systems, where in use.] Pretreatment and flushing shall be complete before system treatment is added to the system. Refer to Section 230300, "Basic Materials and Methods", for additional requirements.
- D. FDA and USDA Approval: Use only FDA and USDA-approved products in systems with direct connection to domestic water systems.
- E. Governing Laws: Ensure that neither products, waste, blowdown, nor other effluents violate local, state, EPA, or other agency regulations in effect in the project area.

2.2 CHILLED WATER AND HEATING WATER SYSTEMS:

[SELECT ONE OF THE FOLLOWING]

- A. **[Chemicals: Provide water treatment products which contain inhibitors that perform the following:**
1. **Form a protective film to prevent corrosion and scale formation.**
 2. **Scavenge oxygen and protect against scale.**
 3. **Remain stable throughout operating temperature range.**
 4. **Are compatible with pump seals and other elements in the system.**
 5. **The inhibitor shall be a boron nitrate scale inhibitor compound, equal to Nalco No. 2536.**
 6. **Water treatment products shall be exactly the same as the chemicals used to treat the existing water system which is being expanded. Provide initial water treatment for the expanded water system with new water piping installed.]**
- B. **[Equipment: For each system, provide a 5 gallon pot-type feeder constructed of materials which are impervious to the products dispensed. Feeder shall be designed for not less than 200 psig operating pressure.]**

[OR]

- C. **[Equipment: The existing water treatment equipment shall be used to inject new water treatment chemicals into the expanded water system.]**
- D. Chemicals: Furnish a [one] [two] year supply of closed system chemical treatment for prevention of corrosion in the system, including consulting services of a water treatment service engineer as described hereinabove. Coordinate delivery of chemicals with the Owner's representative.
- E. Test Kit: Provide test kit and a [one] [two] year supply of reagents for determining proper water conditions.

2.3 CONDENSER WATER SYSTEM:

- A. General: Provide a complete factory-fabricated automatic condenser water treatment system designed to monitor, record, and control:
1. System alkalinity in a pH range that is noncorrosive.
 2. Total dissolved solids (TDS).

3. System blowdown.
 4. Scaling and corrosion.
 5. Eliminate microbiological growth.
- B. **Program:** Use EZ-Board or Factory-Board mounted Nalco CW-Biopac and CW-G.2, Mogul WC-7.1, or an approved equal treatment program with a solid state impulse timer, a pH controller, a single channel event controller and a conductivity controller. The impulse timer shall be activated by an electric contact register water meter after a fixed volume of make-up water enters the system and shall proportionately control chemical feed to inhibit the formation of scale and corrosion. Acid feed for pH control shall be controlled independently by the pH controller using a system pH sensor. Total dissolved solids will be monitored as conductivity by the conductivity controller and shall be controlled through bleed-off. Biocide and algacide feed shall be controlled to inhibit biological growth.
- C. **Equipment:** Provide water treatment equipment including, but not limited to, the following:
1. A prewired NEMA 1 control panel including:
 - a. One solid state timer.
 - b. A pH meter with 0-14 pH range control output contacts with adjustable ranges, alarm contacts with adjustable ranges and a measure/standby switch.
 - c. A single channel event recorder with a one year supply of chart paper with selector switch for recording pH or conductivity.
 - d. An adjustable conductivity controller with a 0-5000 MMHO range.
 - e. Chemical pump starters.
 - f. A main power switch and input fuse.
 - g. HOA Switches for each system facility.
 - h. Door mounted indicating lamps for power on, inhibitor feed, acid feed and bleed-off.
 2. A pH probe with mounting assembly and connecting cable.
 3. A TDS (conductivity) probe with mounting assembly and connecting cable.
 4. Corrosion resistant chemical feed pumps with tubing and extended foot valve assemblies and level sensors (total of four).
 5. In-line sample pump, interlocked with the condenser water pumps.
 6. Makeup water meter with electric contacting register.
 7. Corporation stop and injection assembly.
 8. Solenoid valves for bleed-off and system isolation.
 9. A flow indicator manual control valve for bleed-off.
 10. Bleedoff water meter.
 11. Chemical drum level gauges.
 12. A test kit, consisting of four 10 ml burettes, all necessary glassware, pH color comparator, and a **[one] [two]** year supply of reagents to perform the following analyses:
 - a. M Alkalinity.
 - b. Chloride.
 - c. Calcium hardness.
 - d. pH.
 - e. Inhibitor.
 13. A **[one] [two]** year supply of condenser water treatment to inhibit the formation of scale, corrosion and algae, including consulting services of a water treatment service Engineer as described hereinabove. Coordinate delivery of chemicals with the Owner's representative.

2.4 GLYCOL SYSTEM TREATMENT:

- A. **Chemicals:** Provide water treatment products which contain inhibitors that perform the following:

1. Form a protective film to prevent corrosion and scale formation.
2. Scavenge oxygen and protect against scale.
3. Remain stable throughout operating temperature range.
4. Are compatible with pump seals and other elements in the system.
5. The inhibitor shall be a boron nitrate scale inhibitor compound, equal to Nalco No. 2536 and shall be compatible with the proposed glycol solution to be used.

B. Equipment: For each system, provide a 5 gallon pot-type feeder constructed of materials which are impervious to the products dispensed. Feeder shall be designed for not less than 200 psig operating pressure.

C. Test Kit: Provide test kit and a one year supply of reagents for determining proper water conditions.

2.5 GLYCOL SYSTEM FILLING:

A. General: Furnish and install provisions to allow glycol to be added to the closed loop glycol piping system and to allow system samples to be taken for analysis.

B. Glycol: Add glycol to the filled and treated piping system to provide a 30% glycol/water solution suitable to protect the system from freezing at temperatures down to 5°F. Glycol used for system filling shall be commercial ethylene glycol, Union Carbide Ucartherm, Dow Chemical Dowtherm SR-1, Texaco E.G. Heat Transfer Fluid 100 or an approved equal

C. Test Kit: Provide a test kit for determining the percentage of glycol in the system.

2.6 STEAM BOILER FEEDWATER TREATMENT:

A. General:

1. Provide chemical treatment as required to provide a protective film to prevent corrosion and scale formation, to scavenge oxygen and to protect against scale.
2. Provide a boiler feedwater treatment system to proportionately control chemical treatment and dissolved solids. An impulse timer shall be actuated by an electric contact register water meter after a fixed volume of make-up water passes into the boiler feed system. The impulse timer shall control the pumping of chemical treatment to the boiler, and proportionately control dissolved solids through blowdown.

B. Equipment: Furnish and install water treatment equipment including, but not limited to, the following:

1. A prewired NEMA 1 control panel including:
 - a. One solid state timer.
 - b. A three channel event recorder with a one year supply of chart paper with selector switch for recording pH or conductivity.
 - c. An adjustable conductivity controller with a 40-6000 MMHO range.
 - d. Chemical pump starters.
 - e. A main power switch and input fuse.
 - f. HOA Switches for each system facility.
 - g. Door mounted indicating lamps for power on, oxygen scavenger feed, scale control feed and bleed-off for each boiler.
 - h. Blowdown Test Switch for each boiler.
2. A TDS (conductivity) probe with mounting assembly and connecting cable for each boiler.
3. Corrosion resistant chemical feed pumps with tubing, extended foot valve assemblies and tank assembly.
4. Prepiped blowdown assembly with throttling valve, for each boiler.
5. Boiler injection nozzles.
6. Prefabricated corrosion test coupon bypass assembly.
7. A flow indicator manual control valve for bleed-off, for each blowdown bypass.

8. De-aerator injection nozzle.
9. Water meter with electric contact register for [de-aerator] [boiler] make-up.
10. Chemical tank level gauges.
11. A test kit, consisting of four 10 ml burettes, all necessary glassware, pH color comparator, and a [one] [two] year supply of reagents to perform the following analyses:
 - a. Phosphates.
 - b. M Alkalinity.
 - c. Chloride.
 - d. Calcium hardness.
 - e. pH.
 - f. Inhibitor.
 - g. Neutralizing amines.
12. Furnish [one] [two] year's supply of the chemical treatment to prevent oxygen pitting corrosion in the steam boiler and feedwater piping system. This oxygen scavenger formula will be separate formula fed directly to the feedwater storage section of the de-aerating heater system. The chemical formula provided will be compatible with system materials of construction and operating conditions and will comply with all applicable regulatory agencies. Coordinate delivery of chemicals with the Owner's Representative.
13. A [one] [two] year supply of chemical treatment to inhibit the formation of scale, corrosion and algae, including consulting services of a water treatment service engineer as described hereinabove. Coordinate delivery of chemicals with the Owner's representative.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS PREPARATION:

- A. General: After piping systems are erected and proven free of leaks, administer chemicals required for preparation treatment and flushing. Apply chemicals for the time period and in the concentration recommended by the water treatment manufacturer for this portion of the Work. Refer to Section 230300 for additional treatment and flushing requirements.
- B. Testing: Perform test procedures and submit a written report of test conditions and results to the Engineer. If test results are unsatisfactory, repeat preparation treatment as necessary to achieve test results approved by the Owner's insurance carrier and the Engineer.

3.2 BOILER BOILOUT:

- A. General: Perform boiler boilout using procedures and products as recommended by boiler manufacturer.

3.3 FLUSHING:

- A. General: Drain preparation and boilout products from systems. Flush with clean water until system tests prove systems are free of preparation and boilout products and other contaminants prior to administering system water treatment as specified. Refer to Section 230300 for additional requirements.

3.4 CHILLED WATER AND HEATING WATER SYSTEMS:

- A. General: Install chemical feed and sampling connections in system piping as detailed on the Drawings and as required.
- B. Verification: Verify that pretreatment and flushing have been completed as specified in Section 230300.
- C. Treatment: Install initial treatment in closed systems.

3.5 CONDENSER WATER SYSTEM:

- A. Installation:
 1. Verify that pretreated and flushing have been completed in accordance with Section 230300.

2. Install an extra heavy steel coupling in the circulating water line, welded at 30°F to 45°F angle with inboard end pointing in direction of flow.
 3. Install the corporation stop and injection assembly in the steel coupling with the PVC injector tube inserted completely with discharge end at the center of the circulating water line.
 4. Install the chemical pumps and control panel near the injection point and connect pump discharge line to the injection point.
 5. Install water meter with shut-off valves and bypass.
 6. Install a bleed-off line with gate valve, solenoid valve, and control valve from the circulating water line, discharging into an open funnel which is connected to a floor drain.
 7. Install a 3/4" by-pass line for control sensors across the circulating pump with shut-off valves, solenoid valve, pH probe and housing, conductivity probe and housing and flow indicator.
 8. Provide a 120 volt manual starter (manual reset type) at the control panel and interlocked with the condenser water pumps to prevent pumping treatment and bleed-off without circulation. Wire the control panel to the water meter, chemical pumps, sensing probes and solenoid valves. The 120 volt power supply to the manual starter will be furnished under Division 26.
 9. Provide a 1/2" Schedule 80 A106 pipe for acid from the acid feed pump to the cooling tower basin.
- B. Start-up Procedures: During condenser cooling water system start-up, operate condenser water treating system (after charging with specified chemicals) to maintain the required steady-state characteristics of cooling water. Demonstrate system operation to Owner's operating personnel.
- C. Reports: Prepare certified test report for each required water performance characteristic. Comply with following ASTM standards, where applicable:
1. ASTM D859 - Tests for Silica in Water and Waste Water.
 2. ASTM D1067 - Tests for Acidity or Alkalinity of Water.
 3. ASTM D1068 - Tests for Iron in Water and Waste Water.
 4. ASTM D1126 - Tests for Hardness in Water.
 5. ASTM D1128 - Identification of Types of Microorganisms and Microscopic Matter in Water and Waste.
 6. ASTM D3370 - Sampling Water.
- D. Water Chemistry: Where water chemistry substantiates that pH control is not necessary, chemical feed shall be based on water make-up quantities. Water analysis shall be based on the full parameters of operation and all possible supplies. A water meter on the make-up water shall be used in conjunction with a TDS bleed control. pH control may be omitted where "M" alkalinity does not exceed 500 PPM and pH range is 8.2 to 9.4. Total hardness will be the determining factor along with the technical limitations of the inhibitors.
- 3.6 GLYCOL SYSTEM:
- A. General: Install chemical/glycol feed and sampling connections in system piping as detailed on the Drawings and as required.
 - B. Verification: Verify that pretreatment and flushing have been completed as specified in Section 230300.
 - C. Treatment: Install initial treatment and initial glycol fill in system
- 3.7 STEAM BOILER FEEDWATER SYSTEM:
- A. Installation:
 1. Verify that pretreated and flushing have been completed in accordance with Section 230300.
 2. Install the de-aerator injection nozzle.
 3. Install the boiler injection nozzles.
 4. Install the chemical pumps and control panel near the injection points and connect pump discharge lines to the injection points.

5. Install water meter with shut-off valves and bypass.
6. Install a blowdown line with gate valve, solenoid valve, bypass and control valve for each steam boiler, discharging into the boiler blowdown separator which is connected to a floor drain.
7. Provide a 120 volt manual starters (manual reset type) at the control panel and interlocked with the boiler feed water pumps to prevent pumping treatment and bleed-off without circulation. Wire the control panel to the water meter, chemical pumps, sensing probes and solenoid valves. The 120 volt power supply to the manual starter will be furnished under Division 16.
8. Provide a corrosion test coupon assembly and bypass which will periodically be analyzed by the water treatment company and reports shall be provided to the Owner.

3.8 CHEMICAL STORAGE AREA:

- A. Install water treatment chemicals and equipment inside a curb or slab recess area with floor drain and hose bibb, as shown on the Drawings or required.

3.9 FIELD SERVICE:

- A. Operator Training: Train Owner's personnel in use and operation of water treating systems, including testing, preparation of chemical solution, if applicable, and charging of the chemical solution reservoir. A Program Administration Manual shall be furnished encompassing all systems covered in this Section of the Specifications.
- B. Service Engineer: Furnish the services of a qualified water treatment service engineer to supervise start-up and initial treatment of each system and to instruct the Owner's operating personnel in proper operation and maintenance of the water treatment equipment.
- C. Service Systems and Required Tests: The service engineer shall visit the site on a biweekly basis for the first 2 months of system operation and then on a monthly basis for the remainder of the warranty period [**12 months**] [**24 months**] past final acceptance).
- D. Start-up: None of the water systems to be treated shall be put into operation until initial treatment and operating treatment have been completed. Refer to Section 23 03 00 for pipe cleaning and initial treatment.

3.10 IDENTIFICATION:

- A. Refer to Section 23 03 00 for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 25 00

1.1 SECTION 23 30 00 - HVAC PUMPS

PART 1 - GENERAL

1.2 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.3 DESCRIPTION OF WORK:

- A. Work Included: Provide pumps as specified, scheduled, and indicated.
- B. Types: The types of HVAC pumps required for the project include the following:
1. Chilled water pumps.
 2. Condenser water pumps.
 3. Heating hot water pumps.
 4. Glycol pumps.
 5. Condensate return units.

1.4 QUALITY ASSURANCE:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
1. Allis-Chalmers Corporation.
 2. Armstrong Pumps, Inc.
 3. Aurora Pump Company.
 4. Bell and Gossett, ITT Division.
 5. Ingersol-Rand.
 6. PACO Pumps.
 7. Patterson.
 8. Peerless.
 9. Taco, Inc.
 10. Weinman.
 11. Worthington Pump Division, Dresser Industries.
- 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.

1.5 SUBMITTALS:

- A. Shop drawing submittals shall include, but not be limited to, the following:
1. Pump cut sheets with all pump capacities, characteristics, features, accessories and options clearly indicated.
 2. Pump curves with selection point clearly indicated.
 3. Motor data as required in Section 23 04 00, "Motors and Controllers".
 4. Additional information as required in Section 23 01 00.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver pumps in factory-fabricated water-resistant wrapping.
- B. Handle pumps carefully to avoid damage to material components, enclosure and finish.
- C. Store pumps in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 HORIZONTAL SPLIT CASE PUMPS:

- A. General: Provide double suction, split case, flexible coupled, cast iron casing, bronze fitted centrifugal type, mechanical seal pumps of the size, capacity and head scheduled on the drawings. Pump selections and submittals shall be made using pressure versus flow curves. The selected pump operation point shall have a minimum efficiency as scheduled and impeller diameter shall not exceed **[85%] [the scheduled percentage]** of the cut water diameter for the selected pump casing size. Pump discharge velocity shall not exceed 12'per second. The total dynamic head shall be maximum at no-flow and shall decrease from no flow to design flow. Shutoff head shall be at least 110% of design head but shall not exceed 140% of design head, unless scheduled otherwise. All pump shall have dynamically balanced impellers and the critical speed of all pumps shall be at least 115% of the design speed. Pumps shall be free from flashing and cavitation at all flow rates from 25% to 125% of design flow under suction conditions of the pump installation.
- B. Features: Pumps, casings, flanges and seals shall be suitable for operation at 150 psig or 300 psig minimum as scheduled and shall be suitable for use within the normal temperature operating ranges of the system in which they are installed. Pump suction and discharge flanges shall be minimum Class 125 or 250 ANSI-rated and shall correspond to the scheduled pump casing pressure rating. Pumps shall have carbon steel shafts, stainless steel shaft sleeves, field-replaceable cast iron or bronze casing wear rings, bronze impeller with replaceable bronze wear rings, external seal water piping, cast iron deflectors, stainless steel impeller keys, coated fiber parting gaskets and steel casing studs and bolts.
- C. Pump Casing: The pump casings shall be cast iron members. They shall be split at the horizontal center line of the shaft in each case. The flanges of the upper and lower sections of the casing shall be arranged so that they may be held together rigidly with the use of appropriate bolts. The pump suction and discharge nozzles shall be located in the lower section of the casings. The design shall be such that the rotors of the pumps may be exposed for inspection or for removal by resorting to the expediency of removing the top section of the casing, but without disconnecting any part of the main interconnecting pipe systems.

[VERIFY SEAL TYPE]

- D. Seals: Seals for **[all] [chilled water] [heating hot water] [glycol] [condenser water]** pumps shall be mechanical seals suitable for the working pressure and temperature of the pump and application. All metal seal parts shall be 316 stainless steel. Mechanical seals shall be as manufactured by the John Crane Company and shall be suitable for the service specified. Seals for stuffing box working pressures of 150 psi or 300 psi as scheduled and shall be Type 1**[B]** or Type 2**[B] [unbalanced] [balanced]** seals. Seal material shall be Type BP-66-1D1 for treated fluids up to 180°F and Type XP(66)1D1 for treated fluids from 185°F to 250°F. **[Seals for [all] [chilled water] [heating hot water] [glycol] [condenser water] pumps shall be packing gland seals with five rings of graphite packing, bronze split glands, bronze lantern rings, brass gland clips and stainless steel swing bolts and nuts.]**

[SELECT ONE OF THE FOLLOWING]

- E. [Seal Water Filtration]: The mechanical seals on **[the condenser water] [all]** pumps shall be provided with Dorr-Oliver Type 5 "Doxie" impurity eliminators constructed throughout with 316 stainless steel. Piping shall be copper or Schedule 40 galvanized steel and shall be provided with isolation gate valves and valved bypass piping as shown on the Drawings.]

[OR]

- F. [Seal Water Filtration]: The mechanical seals on **[the condenser water] [all]** pumps shall be provided with AMF Cuno Model 1A1 Cartridge Filter Housings with AMF Cuno Micro-Klean II (Series V30) 5 micron filter cartridges. Piping shall be copper or Schedule 40 galvanized steel and shall be provided with isolation gate valves and valves and valved bypass piping as shown on the Drawings.]

- G. **Bearings:** The pump rotors shall be supported in the case of each pump upon two ball type bearings. One ball bearing shall be located on each side of the pump impeller and each shall be in split bearing housings. The design of the split bearing housings shall be such as to make them dust-tight, grease-tight, water-tight with integral bearing arms cast to the main pump frame. All pumps shall have grease-lubricated ball bearings with grease fittings and relief plugs. Bearings shall have 40,000 hours minimum life for suction pressures below 200 psi and 20,000 hours minimum life for suction pressures 200 psi and above. Bearings shall limit impeller and mechanical seal face deflection to a maximum of 0.002".
- H. **Couplings:** Pump couplings shall be **[Woods Type SC Sure-Flex flexible couplings] [Thomas metallic couplings with stainless steel flexing members]** or an approved equal. Coupling alignment shall be field calibrated to a maximum of 2 mils vibration.
- I. **Pump Bases:** All pumps shall have cast iron or fabricated steel drip lip bases with coupling guards, anchor bolts, provisions for grouting and shall have provisions for collection of all seal and condensation leakage. Motor and pump mounting surfaces shall be machined and the motor mounting shall include provisions for horizontal movement and alignment. Pump bases shall be provided with continuous drip canal around three sides, arranged for drainage to a 3/4" threaded drainage opening. All bases shall have sufficient strength to prevent vibration, warping and misalignment when installed without grouting. Bases on pumps of 20 hp and smaller shall be adequately stiffened to prevent flexing of panels. Bases for pumps 25 hp and larger shall be fabricated of structural steel shapes and shall have a minimum depth of 1/12th of the overall base length or 4" whichever is larger.
- J. **Motors:** Pump motors shall be **[high efficiency, energy efficient]** 1750 rpm **[open dripproof (ODP)] [totally-enclosed, fan cooled (TEFC)]** type and shall be selected to drive the pump through its characteristic curve from zero flow to 125% of design flow without exceeding rated full load nameplate horsepower. Refer to Section 15140 for additional motor requirements.
- K. **Testing:** Pumps with drive motors 10 hp and larger and all pumps rated at 300 psi shall be individually factory pressure and capacity tested after final assembly using shop turbine per Hydraulic Institute Standards and a complete set of test curves shall be obtained. Provide certified copies of test results showing capacity, head, horsepower and efficiency at flow rates from shutoff to 125% of design flow. The certification shall also indicate results of factory dynamic balance and pressure testing.
- L. **[Weatherproof Pumps: The entire pump and motor assembly shall be designed for outdoor use, exposed to weather.]**

2.2 END SUCTION BASE-MOUNTED PUMPS:

- A. **General:** Provide horizontal base mounted, flexible coupled, cast iron casing, bronze fitted, true rear pullout centrifugal type, mechanical seal pumps of the size, capacity and head scheduled on the Drawings. 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. Pump selections and submittals shall be made using pressure verses flow curves. The selected pump operation point shall have a minimum efficiency as scheduled and impeller diameter shall not exceed the scheduled percentage of the cutwater diameter for the selected pump casing size. Pump discharge velocity shall not exceed 12' per second. The total dynamic head shall be maximum at no-flow and shall decrease from no flow to design flow. Shutoff head shall be at least 110% of design head but shall not exceed 140% of design head, unless scheduled otherwise. All pump shall have dynamically balanced impellers and the critical speed of all pumps shall be at least 115% of the design speed. Pumps shall be free from flashing and cavitation at all flow rates from 25% to 125% of design flow under the suction conditions of the pump installation.
- B. **Features:** Pumps, casings, fittings, flanges and seals shall be suitable for operation at 150 psig or 300 psig minimum as scheduled and shall be suitable for use within the normal temperature operating ranges of the system in which they are installed. Pump suction and discharge flanges shall be minimum Class 125 or Class 250 ANSI flanges and shall correspond to the scheduled pump casing pressure rating. Pumps shall have carbon steel shafts, stainless steel sleeves, field replaceable bronze front and rear casing wear rings, bronze impeller **[with replaceable bronze impeller wear rings,]** external seal water piping, stainless steel impeller keys and steel casing bolts.

- C. Seals: Mechanical seals shall be suitable for the working pressure and temperature of the pump application. All metal seal parts shall be 316 stainless steel. Mechanical seals shall be as manufactured by the John Crane Company and shall be suitable for the service specified. Seals for stuffing box working pressures of 150 psi or 300 psi as scheduled and shall be Type 1[B] or Type 2[B] [unbalanced] [balanced] seals. Seal material shall be Type BP(66)1D1 for treated fluids up to 180°F and Type XP(66)1D1 for treated fluids from 181°F to 250°F.

[SELECT ONE OF THE FOLLOWING]

- D. **[Seal Water Filtration: The mechanical seals [on the condenser water] [all] pumps shall be provided with a Dorr-Oliver Type 5 "Doxie" impurity eliminators constructed throughout with 316 stainless steel. Piping shall be copper or Schedule 40 galvanized steel and shall be provided with isolation gate valves and valved bypass piping as shown on the Drawing.]**

[OR]

- E. **[Seal Water Filtration: The mechanical seals on [the condenser water] [all] pumps shall be provided with AMF Cuno Model 1A1 Cartridge Filter Housings with AMF Cuno Micro-Klean II (Series V30) 5 micron filter cartridges. Piping shall be copper or Schedule 40 galvanized steel and shall be provided with isolation gate valves and valved bypass piping as shown on the Drawing.]**
- F. Bearings: All pumps shall have grease-lubricated ball bearings with grease fittings and relief plugs. Bearings shall have 40,000 hours minimum life for suction pressures below 200 psi and 20,000 hours minimum life for suction pressures 200 psi and above. Bearings shall limit impeller and mechanical seal face deflection to a maximum of 0.002".
- G. Couplings: Pump couplings shall be **[Woods Type SC Sure-Flex flexible couplings] [Thomas metallic couplings with stainless steel flexing members]** or an approved equal. Coupling alignment shall be field calibrated to a maximum of 2 mils vibration.
- H. Pump Bases: All pumps shall have cast iron or fabricated steel drip lip bases with coupling guards, anchor bolts, provisions for grouting and shall have provisions for collection of all seal and condensation leakage. Motor and pump mounting surfaces shall be machined and the motor mounting shall include provisions for horizontal movement and alignment. Pump bases shall be provided with continuous drip canal around three sides, arranged for drainage to a 3/4" threaded drainage opening. All bases shall have sufficient strength to prevent vibration, warping and misalignment when installed without grouting. Bases on pumps shall be adequately stiffened to prevent flexing of panels.
- I. Motors: Pump motors shall be **[high efficiency, energy efficient] 1750 rpm [open dripproof (ODP)] [totally-enclosed, fan cooled (TEFC)]** type and shall be selected to drive the pump through its characteristic curve from zero flow to 125% of design flow without exceeding rated full load nameplate horsepower. Refer to Section 23 04 00 for additional motor requirements.
- J. Testing: Pumps with drive motors 10 hp and larger and all pumps rated at 300 psi shall be individually factory pressure capacity tested after final assembly using shop turbine per Hydraulic Institute Standards and a complete set of test curves shall be obtained. Provide certified copies of test results showing capacity, head, horsepower and efficiency at flow rates from shut off to 125% of design flow. The certification shall also indicate results of factory dynamic balance and pressure testing.
- K. **[Weatherproof Pumps: The entire pump and motor assembly shall be designed for outdoor use, exposed to weather.]**

2.3 IN-LINE CENTRIFUGAL PUMPS:

- A. General: Provide circulating pumps with all-bronze construction of the size, type, and capacity scheduled or shown on the Drawings. Pumps shall be fitted with a dynamically balanced brass 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 indicated. The scheduled working pressure applies to the entire pump assembly.

2.4 CONDENSATE RETURN UNITS:

- A. General: Provide a condensate pump/receiver unit with capacities and electrical characteristics as scheduled or shown on the Drawings.
- B. Receiver: Receiver shall be of the vented cast iron design with capacity as scheduled on the Drawings. Connections to the receiver shall include inlet, vent, drain and gauge glass. The condensate receiver shall be furnished with a back angle thermometer and a brass water level gauge assembly complete with shut-off valve and protector rods. A full size vent from the receiver shall be routed **[through the building roof] [as shown on the Drawings]**.
- C. Pumps: Pumps shall be vertical flange mounted, bronze fitted duplex pumps with a bronze case wearing ring and a mechanical seal with 316 stainless steel metal parts, Buna-N bellows, Ni-resist seat and carbon washer. The pumps shall be close coupled to ODP motors with characteristics as scheduled. Motor shafts shall be stainless steel. The pumps shall be flange mounted to the receiver.
- D. 3-Way Valve: The receiver inlet connection shall consist of a 3-way strainer valve. The valve shall allow condensate flow to be channeled through the strainer, bypassed around the strainer or completely shutoff.
- E. Control Panel: The control panel shall be wall mounted, NEMA 1 construction, prewired for a single point electrical input with the following components:
 - 1. Two FVNR magnetic starters with three phase overload protection, fused disconnect switches and green run indicator lights for each pump.
 - 2. Two HOA selector switches, one for each pump.
 - 3. One mechanical alternator to switch lead and lag pump at each pump start.
 - 4. Adjustable float switch to start and stop lead pump and for high level alarm.
 - 5. One fused Control Power Transformer.
 - 6. One set of engraved nameplates for all control switches and indicator lights.
 - 7. One set of N.C. auxiliary contacts for high condensate alarm. Contacts shall be held open under normal conditions and shall be closed under alarm. **[Contacts will be monitored [_____]]**.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. General: Installer shall examine 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.

3.2 INSTALLATION OF PUMPS:

- A. General: Install pumps where shown, 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. Base-Mounted Pumps: Pumps shall be leveled, bolted, and grouted to pump bases. Piping shall be arranged so pump cases are not subjected to any piping forces. Contractor shall check for proper angular and concentric alignment of pumps and motors and shall get Engineer's approval of this alignment before pumps are operated. Pump bases shall be grouted in place after pump alignment.
- C. Alignment: Check alignment and, where necessary, realign shafts of motors and pumps within tolerances recommended by manufacturer.
- D. Housekeeping Pads/Vibration Isolation: Refer to Section 23 03 00 and Section 23 05 48 for applicable requirements.
- E. Drain Lines: Provide a drain line (3/4" minimum) from each pump drip base to the nearest floor drain.
- F. Casing Relief Valves: Provide individual casing relief drain lines from each pump casing relief valve for the nearest floor drain.

3.3 ELECTRICAL CONNECTIONS:

- A. Power: Coordinate pump power connections with Division 26.

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

3.4 FIELD QUALITY CONTROL AND STARTUP:

- A. Start-up: The pump supplier shall provide pump checkout, start-up, testing and adjusting of system components.
- B. 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 which cannot be satisfactorily corrected.
- C. Condensate Return Unit: Unit installation checkout, start-up, and adjustment shall be performed by the installing Contractor.
- D. Seals: After pumps have been in operation for 90 days, the Contractor shall check all seals and replace any which are defective.

3.5 TESTING:

- A. General: Test and adjust all installed pumps and controllers to verify proper operation as specified herein and as recommended by the manufacturers. Where specified hereinabove, start-up, testing, and adjustment shall be provided by a representative of the equipment supplier.
- B. Functional Tests: Test controllers and annunciators to verify that all control, alarm, and indicator functions operate properly and to verify that pump discharge pressures and flows are as specified.
- C. Refer to Section 23 05 93 for additional start-up, testing, and adjustment requirements.

3.6 IDENTIFICATION:

- A. Refer to Section 23 03 00 for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 30 00

SECTION 23 31 13 - DUCTWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide metal ductwork systems as shown on the Drawings and as specified herein.
- B. System Types: The types of ductwork systems 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.
 6. Gas-fired equipment breeching and flue.
 7. Special exhaust systems.

[EDIT TO SUIT PROJECT REQUIREMENTS

- C. VAV Supply Air Ductwork Upstream of Terminal Units: Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [] fpm and pressures up to **[+3"]** [] wg. Ductwork shall be **[externally insulated]**. **[Provide [one inch (1")] [2"] [external insulation] on air handling unit discharge where shown on the Drawings.]**
- D. Supply Air Ductwork Downstream of Terminal Units: Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [] fpm and pressures up to **[+2"]** [] wg. Ductwork shall be **externally insulated**.
- E. Constant Volume Supply Air Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [] fpm and pressures up to **[+2"]** [] wg. Ductwork shall be **[externally insulated]** **[Provide [one inch (1")] [2"] external insulation on air handling unit discharge where shown on the Drawings.]**
- F. Acoustic Supply Air Ductwork: Ductwork, where noted or shown on the Drawings shall be United McGill K-27 **[spiral]** **[longitudinal]** seam, welded galvanized sheet metal double wall round duct and fittings designed for velocities up to **[2500]** [] fpm and pressures up to **[+3"]** [] wg. Duct shall have **[one inch 1"] [1-1/2"]** insulation between the outer wall and the perforated sheet metal internal wall. NOTE: Round ductwork requires FP&C approval.
- G. Outside Air Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [] fpm and pressures up to **[+3"]** [] wg. Ductwork shall be externally insulated.
- H. Garage Supply and Exhaust Ductwork: Ductwork shall be round or flat oval spiral seam sheet metal ductwork designed for velocities up to **[4000]** [] fpm and pressures up to **[+4"]** [] wg for supply and **[-4"]** [] wg for exhaust. Garage supply and exhaust ductwork shall not be insulated.
- I. Stairwell Pressurization Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to **[4000]** [] fpm and pressures up to **[+3"]** [] wg. Stairwell pressurization ductwork shall not be insulated.
- J. Return Air Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [] fpm and pressures up to **[-1"]** [] wg. Ductwork used for return air boots and elbows and other return air ductwork where shown on the Drawings shall be shall be externally insulated with one inch (1")) insulation.

- K. General Exhaust Ductwork: General exhaust ductwork shall include all exhaust ductwork which is not otherwise specified. Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [_____] fpm and pressures up to **[-2"] [-_____"] wg**. General exhaust duct shall be uninsulated, except that exhaust ductwork which passes through nonconditioned spaces shall be externally insulated **[and]** horizontal exhaust ductwork from/in toilets shall be externally insulated with one inch (1") insulation.
- L. Kitchen Exhaust Ductwork: Ductwork shall be welded **[316L stainless]** **[black]** steel designed for velocities up to 2500 fpm and pressures up to **[-3"] [_____"] wg** and shall be in accordance with NFPA 96. Ductwork shall be wrapped with **[a 2" calcium silicate insulation as specified in Section 230700]** **[a rated fire blanket insulation as specified in Section 230700]** **[and]** **[a [one (1)] [2] hour rated drywall enclosure]**.
- M. Dishwasher Exhaust Ductwork: Ductwork shall be welded 316L stainless steel or aluminum ductwork designed for velocities up to 2500 fpm and pressures up to **[-2"] [_____"] wg**. Ductwork shall not be insulated, except that ductwork which passes through nonconditioned spaces shall be externally insulated.
- N. Smoke Exhaust Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to **[4000]** [_____] fpm and pressures up to **[-3"] [-_____"] wg**. Smoke exhaust ductwork shall not be insulated, **[except that ductwork within [10'] [_____'] of building exterior wall penetrations shall be externally insulated]**.
- O. Laboratory Hood Exhaust Ductwork: Ductwork shall be **[welded 316L stainless steel]** **[fiberglass reinforced plastic (FRP)]** ductwork designed for velocities up to **[4000]** [_____] fpm and pressures up to **[-6"] [-_____"] wg**. Laboratory exhaust ductwork shall not be insulated except that ductwork which passes through nonconditioned spaces shall be externally insulated.
- P. Underground Supply and Return Ductwork: Ductwork shall be rigid round ductwork designed for velocities up to 2500 fpm and pressures up to **[+2"] [+_____"] wg** for supply and **[-2"] [-_____"] wg** for return. Supply and return ductwork shall not be insulated.
- Q. 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 option, where approved in writing, in advance, by the Engineer.
- R. Breeching and Flue: Breeching and flue for **[boilers]** **[and]** **[water heaters]** shall be Type **["A"] ["B"]** flue. **[Breeching and flue shall be insulated as specified in Section 23 07 00.]**
- S. Ductwrap Insulation: Refer to Section 23 07 00, "System Insulation", for external ductwrap insulation.
- T. Ductwork Accessories: Refer to Section 23 31 14, "Ductwork Accessories", for accessories and specialties related to ductwork systems and installation.
- U. Basic Materials and Methods: Refer to Section 23 03 00, "Basic Materials and Methods", for basic materials and methods related to mechanical construction.

1.3 QUALITY ASSURANCE:

- A. SMACNA Standards: Comply with Sheet Metal and Air Conditioning Contractors National Association (SMACNA), HVAC Duct Construction Standards, Metal and Flexible, Latest Edition recommendations for fabrication, construction, details, and installation procedures, except as otherwise indicated on the Drawings or in these Specifications.
- B. ASHRAE Standards: Comply with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards and recommendations, except as otherwise indicated on the Drawings or in these Specifications.

1.4 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
1. Ductwork submittals shall include ductwork fabrication drawings and submittal data on ductwork specialties and construction details.

2. Ductwork fabrication drawings shall be drawings to scale on **[1/8"] [or] [1/4"]** scale building floor plans and shall indicate duct sizes, duct material, duct insulation type, locations of transverse joints, fittings, ductwork bottom elevation, offsets, ductwork specialties, flexible connections, flexible ductwork, fire and fire/smoke dampers and all other information required for coordination with other trades and fabrication of ductwork. All fire and fire/smoke partitions shall be clearly designated on the ductwork shop drawings. Ductwork fabrication drawings shall be coordinated with other trades and building construction prior to submittal for approval.
3. Duct specialties and construction details including, but not limited to information on duct construction and materials, transverse and longitudinal joints, cross-breaking or transverse beading, dampers, flexible connectors, fittings, transitions, elbows, control, fire and fire/smoke damper connections, branch taps, turning vanes, access doors and other required duct specialties and construction details.
4. Cut sheets on flexible ductwork and related taps and accessories.
5. Cut sheets on breeching and flue piping materials and accessories, including a complete flue design layout.
6. Duct system leakage test procedures and reporting forms.
7. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver ductwork materials to the site in suitable packaging to prevent damage and exposure to weather.
- B. Store ductwork in dry areas, where it is not exposed to damage. Crib stored ductwork off of floors to prevent water damage.
- C. Handle ductwork to prevent damage.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS:

- A. Sheet Metal: Ductwork shall be constructed using prime G90 galvanized lock-forming quality or coil steel in widths up to 60", conforming to ASTM A924/A924M-74, A653 and A653M, **[UMC requirements]** and using gauges selected by application, based upon applicable SMACNA Standards.
- B. Stainless Steel: Ductwork shall be constructed using 316L sheet or roll stainless steel in widths up to 60" and using gauges selected by application, based upon applicable SMACNA Standards **[and NFPA 96 requirements]**.
- C. Black Steel: Ductwork shall be constructed using sheet or roll black steel in widths up to 60" and using gauges selected by application, based upon applicable SMACNA standards and NFPA 96 requirements.
- D. Aluminum: Ductwork shall be constructed using sheet or roll aluminum in widths up to 60" and using gauges selected by application, based upon applicable SMACNA standards.
- E. Labeling: Ductwork materials shall be stenciled on maximum 10'centers with the manufacturer's name and material gauge. Stenciling shall be visible after duct is fabricated and installed.
- F. 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.

2.2 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 nonhardening, nonmigrating 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. Sealers shall be as follows:

1. Sealer shall have a high solids content.
 2. Sealer shall have a high adhesive and cohesive strength and shall bond to both degreased and non-degreased metals.
 3. Sealer shall conform to NFPA 90-A requirements and be UL-labeled for ductwork applications.
 4. Sealer and related installation materials and methods shall be:
 - a. Hardcast Type 601 Iron Grip Duct Sealant.
 - b. United McGill Corporation United Duct Sealer.
 - c. Foster Type 30-02 High Velocity Duct Seal.
 - d. Transcontinental Equipment Ltd. Multipurpose Water Based Duct Sealer.
- 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. Exposed Stainless Steel: Provide matching stainless steel supports for exposed stainless steel ductwork.

2.3 DUCTLINER:

- A. Acoustical Ductliner: Provide Schuller Permacote Linacoustic Standard/HP or Owens-Corning Aeroflex [1/2"] [1"] [1-1/2"] [2"] thick fiberglass ductliner with an NCR of [0.55] [0.70] [0.90] [1.00] or greater per ASTM C1071, a thermal conductivity of 0.31 BTU in/(hr ft² °F) and friction correction factor no greater than 1.02 at 500 fpm. All ductliner shall be guaranteed against delamination up to 3000 fpm velocities. Ductliner shall be have a surface coating formulated with an immobilized, EPA-registered, anti-microbial agent so it will not support the growth of fungus or bacteria.
- B. Ductliner Adhesive: Provide non-flammable adhesives 3M #37, St. Clair R41B, Foster 85-11 or Foster 85-20, which comply with NFPA 90A and ASC-A-7001 by The Adhesive and Sealant Council, Inc. (see SMACNA standards).
- C. Ductliner Fasteners: Comply with SMACNA requirements.

2.4 FLEXIBLE DUCT:

- A. General: Insulated flexible duct shall be a factory fabricated assembly consisting of an inner liner, fiberglass insulation and a vapor barrier outer jacket.
- B. Inner Liner: The inner liner shall consist of a galvanized steel helix mechanically securing an inner liner composed of a tri-laminate of aluminum foil, fiberglass and aluminized polyester for applications upstream of HVAC terminal units and shall consist of a galvanized steel helix mechanically securing an inner liner composed of a SPUNBOND nylon fabric for applications downstream of HVAC terminal units.
- C. Insulation: Duct liner shall be wrapped with a nominal one inch (1") thick fiberglass insulation blanket with a maximum thermal conductance C Factor of 0.23 Btu/hr/sf/°F.
- D. Outer Jacket: Insulation shall be covered with a reinforced metalized aluminum vapor barrier jacket with a maximum permeability of 0.05 Perm per ASTM E96, Procedure A.
- E. Pressure Ratings: Flexible duct for applications upstream of HVAC terminal units shall be rated for a minimum of 12" positive and 5" negative internal working pressure. Flexible duct for air device applications shall be rated for 6" positive and 4" negative internal working pressure. Flexible duct shall be suitable for operation at temperatures up to 120°F.
- F. Sound Attenuation: Flexible duct for air device applications shall be designed to provide sound attenuation and a 9' length of 8" duct shall have typical insertion losses (IL), in dB, as follows:
- | Octave Band | 2 | 3 | 4 | 5 | 6 | 7 |
|--------------------------------|----|----|----|----|----|----|
| Straight Duct at 2500 fpm flow | 9 | 27 | 27 | 32 | 33 | 37 |
| 90° Bend Duct at 2500 fpm flow | 18 | 31 | 34 | 37 | 34 | 38 |
- G. Codes/Standards: Flexible duct shall be listed as Class 1 Air Duct per UL 181 and shall comply with NFPA 90A and 90B.

- H. **Fire Ratings:** Flexible duct shall have a flame spread rating of less than 25 and a smoke developed rating of less than 50.
- I. **Clamps:** Terminal unit flexible duct inner liner shall be secured using Flexmaster LS Series or approved equal 1/2" wide positive locking stainless steel straps. Air device flexible duct outer jackets shall be secured using Panduit Corporation, Ideal or an approved equal 0.35" wide self-locking nylon straps.
- J. **Terminal Unit Flexible Duct Taps:** All take-offs for HVAC terminal units shall be conical bellmouth taps equal to a Flexmaster CB conical bellmouth fitting, or side take offs without dampers equal to a Flexmaster 45° STO fittings. Fittings shall be minimum 26 ga. Galvanized sheetmetal.
- K. **Air Device Flexible Duct Taps:** All round take-offs for air devices shall be made with a damper spin-collar, equal to a Flexmaster FLD dampered spin fitting. Where the duct height does not allow the use of a spin-in fitting, use 45° STOD side take offs with dampers, equal to Flexmaster 45° STOD STOD Fittings. Dampers shall be provided with full length 3/8" square shafts secured to the damper blade with a minimum of 2 U-bolts, nylon bearings, insulation build out, heavy duty locking hand quadrants and integral flexible duct retention beads. Fittings and damper blades shall be minimum 26 ga. galvanized sheetmetal for sizes up to 10" and minimum 24 ga. galvanized sheetmetal for sizes up 12" and larger.
- L. **Manufacturers:** Flexible duct for applications upstream of HVAC terminal units shall be Flexmaster Type 3M or an approved equal. Flexible duct for air device applications shall be Flexmaster Type 6M Acoustical or an approved equal.

2.5 UNDERGROUND DUCTWORK:

[SELECT ONE OF THE FOLLOWING]

- A. **[Coated Sheet Metal Ductwork:** Provide a system of coated sheet metal ductwork as manufactured by Foremost Manufacturing Company, Southfield, Michigan or an approved equal.]

[INSERT TEXT ON PRODUCT]

[OR]

- B. **[Rigid Round Fiberglass Ductwork:** Provide a system of [insulated] rigid round fiberglass ductwork as manufactured by Peabody Spunstrand or an approved equal.]
- C. **[Construction:** Ductwork and fittings shall be constructed of continuous fiberglass strands, impregnated with polyester corrosion resistant resin. Duct shall have ICBO, BOCA and SBCCI approvals including a Class 1 inner liner and compliance with UMC Standard 10-1 for non-metallic ducts in accordance with UL 181.]
- D. **[Duct joints shall be [made using an internal steel sleeve secured with sheet metal screws. Joints shall then be sealed using an extruded beam of Presstite No. 579.6 or an approved equal non-hardening waterproof mastic and then wrapping the entire joint including the screw heads with Polykin 260 foilastic tape, nUSHUA 357 TAPE OR AN APPROVED EQUAL.] [of the wet lay-up type in strict accordance with the manufacturer's instructions, including thoroughly cleaning and sanding the \areas to be h\joined and using polyester resin and fiberglass mat and/or woven roving.]**
- E. **[Insulation:** Ductwork shall be factory insulated to an insulating value of R-[2] [4] [6] [8].]

2.6 FLUE AND BREECHING:

[VERIFY PROJECT REQUIREMENTS]

- A. **Flues:** Flues for boilers shall comply with NFPA requirements for Type ["A"] or ["B"] flue as required. A UL factory-fabricated stack rated for such duty may be used or a stack fabricated of not less than 10 gauge steel, welded and insulated as specified under Section 23 07 00, "System Insulation", of these Specifications, including terminal caps may be used.
- B. **Breeching:** Boiler breeching shall be in accordance with SMACNA Manual recommendations.

- C. **[Fabricated Flues:** Fabricated flues shall be 10 gauge black steel with continuously welded longitudinal and transverse joints. Provide full ring sized non-asbestos gaskets at all flanged connections. Each flue shall be constructed to allow for proper expansion and contraction. Flues shall be flashed and counterflashed with 16 gauge galvanized steel at roof penetrations. Refer to Section 23 07 00 for insulation of field-fabricated flues.]
- D. **[Type "A" Flues:** Factory-built flues shall be laboratory tested and listed by the Underwriters' Laboratories, Inc. for use with the specified equipment burning gas or liquid fuels as described in NFPA 211, which produces exhausted flue gases at a temperature not exceeding 1400°F under continuous operating conditions.]
1. **[Construction:** Double wall flue shall have an outer jacket of [Type 304 stainless] or [aluminum coated] steel 0.025" thick for sizes 6" thru 24" and 0.034" thick for larger diameters. There shall be minimum one inch (1") air space between the walls. The inner gas carrying pipe shall be Type 304 stainless steel. The inner liner shall be 0.035" nominal thickness for all diameters. Flues shall comply with all national safety standards and building codes when installed according the manufacturer's preprinted installation instructions and the limits of its listing.]
 2. **[Joints:** Inner pipe joints shall be sealed by use of V bands and RTV Silicone Sealant for flue gas temperature up to 600°F. For flue gas temperatures above 600°F, joints shall be sealed with V bands and High Temperature Joint Cement as outlined in the installation instructions supplied by the manufacturer.]
 3. **[Manufacturers:** Flues shall be Model PS as manufactured by Selkite Metalbestos or approved equal.]
- E. **[Type "B" Flues:** Provide UL-listed and labeled Type "B" double wall gas vents with heavy gauge galvanized steel outer wall and aluminum inner wall. Male end of pipe shall be crimped and shall have locking clips. Female end of pipe shall have slots to receive the locking clips. Each assembly shall have all components necessary, including pipe sections, supports, tees, elbows, adapters, spacers, increasers, plates, bands, roof or wall thimbles, roof flashings and storm collars, etc. and shall be by same manufacturer. Chimney shall allow installation by use of twist-lock threaded couplers or steel clamp type bands. Internal liner shall not be pierced by sheet metal screws and shall be installed in accordance with manufacturers' recommendations. Flues shall be as manufactured by Amer-i-vent, Thor-Vent or Dura-vent.]
- F. **[Termination:** Flues extending above the roof shall be terminated as required by local codes or as required by NFPA 211, whichever is more stringent and shall be a minimum of 8'above the finished roof. Wind bracing or tiebacks shall be provided as required.]
- G. **[Design:** The actual design of each vent flue system shall follow the layout shown on the drawings but shall be completely laid out and calculated by the flue manufacturer to suit actual equipment served, field conditions and thermal expansion. The flue vent system shall be complete, including, but not limited to: straight sections, elbows, offsets, increasers, tees, equipment connections, supports, drains, ventilated roof thimble/flashing assemblies, stack caps and other required accessories. If recommended by the manufacturer for the proposed installation a drain section with drain piping and trap shall be provided on vertical stacks.]
- H. **[Finish:** All parts of the flues which are exposed outdoors and which are not stainless steel shall be protected by one base coat and two finish coats of series 4200-4300 Rust-O-Leum Corporation heat resistant paint. Paint color to be selected by approved the Architect.]
- I. **[Flue Vent Caps:** Terminate all flue vent [4'] or [as required by local code] above finished roof level with a fluecap. Fluecaps shall be stainless steel, Breidert Type "L" Air-X-Hausters or approved equal. Units shall have birdscreen and self-flashing galvanized bases. Provide special collars or adapters as required to fit cap to flue. Coordinate details of installation with all trades.]

PART 3 - EXECUTION

3.1 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". Duct sizes shown are clear inside dimensions. Where ductliner is specified, increase each dimension to accommodate liner.
 - B. Route all duct tight to underside of structure, unless otherwise noted or required for coordination. All ductwork shall be top level with bottom and side transitions only. The Mechanical Contractor shall be held responsible for coordinating with all other trades prior to the construction or installation of ductwork. Some ductwork may require the use of S-drive joints, flat seams or offsets to allow installation of other ducts or equipment. Use 45 degree radius elbows (center line radius 1.5 times duct height) to rise up and drop down when crossing ductwork or other material. The Mechanical Contractor shall be responsible for coordination of all such work with the General Contractor and other Subcontractors as required. Minimum bottom of duct elevation above finished floor shall be as noted on the Drawings, where applicable.
 - C. Adhere to the Drawings for routing and location of ductwork as closely as possible. Ductwork shop drawings shall be made after job site measurements are made and shall be coordinated with all other trade. Ductwork construction details and materials shall be submitted and approved prior to fabrication of any ductwork.
 - D. All ductwork shown on the Drawings, specified or required for the heating, ventilating and air conditioning systems shall be constructed and erected in a first class workmanlike manner. The 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. After the system is in operation, should these defects occur, they shall be corrected as directed by the Engineer.
 - E. 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.
 - F. 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.
 - G. Where ducts, exposed to view (including equipment rooms), pass through walls, floors or ceilings, furnish and install sheet metal collars around the duct.
 - H. When the Mechanical Contractor submits revised duct sizes for review by the Engineer or requests to substitute rectangular, round or flat oval duct sizes for rectangular, round or flat oval spiral duct, substitute sizes shall be based on equivalent hydraulic diameter as calculated by ASHRAE formulae for equivalent friction loss and airflow.
 - I. **[The round and flat oval high pressure, high velocity ductwork on the project was sized using the static regain methods. Any significant deviations from the design shown on the drawings (as determined by the Engineer) will require that the Contractor submit static regain calculations for the entire duct system in which the change occurs.]**
 - J. 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.
 - K. Ductwork which is exposed to weather shall have soldered joints and seams and shall be painted with a suitable epoxy coating.
- 3.2 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. Where ductwork is concealed, bottom of duct shall be a minimum of 8" above the ceiling unless otherwise noted. Where ductwork is exposed, bottom of horizontal duct shall be a minimum of 6'-6" above finished floor. Where ductwork is exposed in occupied areas it shall be tight to the structure and the bottom of the duct shall be minimum **80"** above finished floor.
- 3.3 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) Tables 1-3 through 1-13. Minimum aluminum gauges and reinforcement shall be in accordance with SDCS Tables 1-14 through 1-16. Reinforcing shall be installed per SDCS Fig. 1-9 through 1-12.
 2. Round Ductwork: Minimum metal gauges for longitudinal and spiral seam round ductwork shall be in accordance with SDCS Table 3-2. Minimum aluminum gauges for longitudinal and spiral seam round ductwork shall be in accordance with SDCS Table 3-3. 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 Fig. 1-4 and 1-5. 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 Fig. 1-5. 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 Fig. 3-2, properly secured and sealed. Draw bands shall not be used on round ductwork. Longitudinal and spiral seams shall be constructed in accordance with SDCS Fig. 3-1.
 4. Ductwork Sealing: Seal all longitudinal and transverse ductwork joints and seams using SMACNA ductwork sealant and 3" wide open weave tape to provide positive seal. Sufficient sealant shall be used to completely imbed the cloth.
- C. Connections and Take-offs:
1. Rectangular Ductwork: Parallel flow branches shall be constructed using radius elbow take-offs in accordance with SDCS Fig. 2-7. Branch duct connections shall be 45 degree entry expanded taps constructed in accordance with SDCS Fig. 2-8. Duct-mounted coil connections shall be constructed in accordance with SDCS Fig. 2-11.
 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.
 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 Fig. 2-2. 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 Fig. 2-3 and 2-4.
2. Round Ductwork: Provide radius elbows of the stamped or segmented type constructed in accordance with SDCS Fig. 3-3. 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 Fig. 2-9 (type 2 and 3 only) and 2-10 (exclude C and E).

F. Air Device Connections: Make connections to air devices and fabricate air device plenums as detailed on the Drawings and in accordance with SDCS Fig. 2-16 through 2-18.

3.4 DUCTLINER:

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".] Ductliner for velocities over 2500 fpm shall be as specified except a perforated metal liner shall be used over ductliner for securement, in lieu of fasteners. Ductliner installation and fasteners shall comply with SDCS Fig. 2-22 through 2-25.

3.5 DUCTWORK 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. Attachment to Structure: Provide hanger attachment to the building structure as specified in Section 230300, "Basic Materials and Methods", and in accordance with SDCS Fig. 4-1 through 4-3.
3. Hangers: Hangers shall be strap or rod sized in accordance with SDCS Table 4-1 and 4-2. 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 Fig. 4-4.
4. 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. Duct shall have at least one pair of supports 8'-0" on centers according to the following:

<u>Angle Length</u>	<u>Angle</u>	<u>Rod Diameter</u>
4'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
6'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
8'-0"	2" x 2" x 1/8"	5/16"
10'-0"	3" x 3" x 1/8"	3/8"

5. 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 hereinbelow. Bends in any length of flexible duct shall not exceed 45 degrees for HVAC terminal unit connections or 90 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 1'-6" for HVAC terminal unit connections or 8'-0" for air device connections. Where longer runs are required, provide externally insulated rigid duct extensions.
2. Supports: Where flexible duct extension exceeds 36", horizontally, a support shall be provided. Duct shall be suspended on 36" centers with a minimum 3/4" wide flat banding material and a minimum 6" wide sheet metal protective saddle. Refer to SDCS Fig. 3-9 and 3-10 and Page 3-17 for additional requirements.
3. Terminal Unit Flexible Duct Connections: All flexible duct connections upstream of HVAC terminal units shall be made by turning back the insulation and securing the inner liner with duct sealer and 1/2" wide positive locking stainless steel straps. The insulation shall then be placed over the joint and sealed on the exterior with self-locking nylon straps and an approved metalized duct tape. Refer to SDCS Page 3-13 and 3-15 for additional requirements.

4. Air Device Flexible Duct Connections: All air device flexible duct connections shall be made by turning back the insulation and securing the inner liner with 1/2" wide positive locking stainless steel straps or self-locking nylon straps and sealing with an approved metalized duct tape. The insulation shall then be placed over the joint and sealed on the exterior with an approved metalized duct tape. Spin-ins for air device taps shall be installed with their damper axis parallel to air flow. Refer to SDCS Page 3-13 and 3-15 for additional requirements.

H. Duct Mounted Devices:

1. Install duct mounted sensors and control devices furnished under **[Section 23 06 00, "Building Controls"] [Division 23]**. Provide access doors at each duct mounted control device. Coordinate location of devices and installation requirements with the **[Section 23 06 00] [Division 23]** 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] [holes]** in ductwork at locations shown on the drawings and 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.

3.6 KITCHEN EXHAUST DUCTWORK:

- A. General: All kitchen exhaust ductwork serving kitchen hoods, ranges and ovens shall be fabricated of minimum **[18 gauge 316 stainless] [16 gauge black] steel** with liquid tight continuous external welds in accordance with NFPA 96 and applicable SMACNA Standards. Access doors of the type, size and spacing required by NFPA and as shown on the drawings shall be provided. No turning vanes or other interior intrusions shall be installed in kitchen exhaust ductwork. All changes in direction shall be with radius elbows (center line radius equals 1.5 x duct width). **[Refer to Section 23 07 00 for kitchen exhaust ductwork insulation.]** Slope duct towards hood connections and cleanout points as shown on the drawings. Coordinate required rated enclosure of kitchen exhaust duct with the General Contractor. Provide rated access doors for installation by the General Contractor at duct access door locations. Refer to Section 3.03 for general fabrication requirements.
- B. Coordination: Contractor shall not fabricate any final connections to kitchen equipment until he has received final shop drawings from the kitchen equipment Contractor. There shall be no turning vanes or other obstructions in kitchen equipment exhaust duct to accumulate grease. Braze or weld kitchen duct seams externally. Comply with NFPA and local codes.
- C. Drains: Ductwork for vapor-producing kitchen equipment shall be pitched to drain back to the kitchen equipment. In the event low points are required at points other than at the equipment, extend one inch (1") copper drains from low points to the nearest floor drain as an open-sight drain.

3.7 STAINLESS STEEL EXHAUST DUCT:

- A. General: Stainless steel exhaust duct shall be rectangular or round duct fabricated with minimum 20 gauge 316L stainless steel with liquid tight continuous external welds and shall conform in all respects to NFPA 45 and applicable SMACNA Standards. Ducts shall have access panels on the side of the duct large enough to permit inspection and cleaning at each change of direction and at 50' on center for horizontal runs. Access panels shall be of the same material or gauge as the duct and shall be liquid tight when in place. Refer to Section 3.03 for general fabrication requirements.
- B. Duct material shall be Type 316L stainless steel with welded air and water tight construction. Welding of duct work materials shall use a MIG or TIG welder and 316L stainless steel feed wire/rods. All welding shall be fully compatible with the materials being welded and finished welds shall have the same level of corrosion resistance which shall equal that of the material being joined. All duct welding shall be performed by certified welders.
- C. Metal gauges and construction shall be as specified in the SMACNA "Round Industrial Duct Construction" Manual for negative pressures up to **[6" wg]**. Minimum metal gauge shall be 20 gauge.
- D. Duct construction shall be straight longitudinal welded seam with welded transverse joints. Elbows shall be die-formed radius construction with a "straight" longitudinal seam and a minimum radius of 1.5 duct diameters. Round elbows shall be minimum five gore type.

- E. Tees and laterals shall be welded 45 degree or 90 degree saddle taps as shown on the Drawings.
 - F. Fire dampers and control dampers (except exhaust terminal units and fan isolation dampers) shall not be installed in stainless steel exhaust ducts.
 - G. Ductwork shall be supported per Section IV of the SMACNA "HVAC Duct Construction Standards- Metal and Flexible", Latest Edition. Duct hanger and support materials on the roof shall be constructed of 316L stainless steel.
 - H. Exhaust plenums shall be constructed of 316L stainless steel welded air tight construction. Plenums shall be externally reinforced using stainless steel angle welded around the outside of the plenum to form a rigid frame. Finished and reinforced plenum shall be capable of withstanding negative pressures between **[2" and 6"]** [_____] S.P. without flexing or inward bowing.
- 3.8 UNDERGROUND DUCTWORK:
- A. General: Underground ductwork shall be suitable for use as shown on the Drawings.
 - B. Installation: The ductwork shall be installed in accordance with the manufacturer's recommendations in a 4" bed of peagravel or dry sand with backfill using peagravel or dry sand to 8" above the top of the duct. Refer to Section 220000 for additional backfill requirements. All underground ductwork shall be leak-tested to 4" wg prior to cover-up. **[Ductwork coating damage shall be repaired as directed by the duct system manufacturer, prior to backfill.]** A slab moisture barrier shall be installed under the ductwork in the trench. Care shall be taken during backfill and pouring of the slab to avoid shock loads and passing of heavy equipment over the installed ductwork. Refer to SDCS Fig. 3-11 and 3-12 for additional requirements.
- 3.9 FLUE AND BREECHING:
- A. General: Install flues and breeching in accordance with the flue manufacturer recommendations and in accordance with SDCS Fig. 2-20.
- 3.10 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.
- [VERIFY PROJECT REQUIREMENTS]**
- 3.11 TESTING:
- A. General: Provide duct integrity and leakage testing for all supply **[, return]** and exhaust ductwork installed on the project. Testing shall be in accordance with the SMACNA HVAC Air Duct Leakage Test Manual, Latest Edition, (DLTM) and shall include, but not be limited to:
 1. Test Complete Systems: Duct systems shall be tested as complete systems (e.g. from air handling equipment to terminal units/air devices, from terminal units to air devices or from air devices to exhaust (return fans). Duct systems shall not be tested in partial sections, unless approved in writing by the Engineer.
 2. Preparation for Testing: Duct system installation must be complete, including, but not limited to, fittings, spin-ins, taps, access doors, hangers, test ports/holes, dampers and other system components. Temporary caps shall be installed at the system inlet (supply air system), system outlet (exhaust/return air systems) and at all terminal unit/air device taps.
 3. Leakage Calculations: Prior to testing a duct system, the permissible leakage rate in cfm shall be calculated based on the square feet of duct surface and the duct system leakage classification.

4. Test Configuration: The configuration for testing shall be similar to DLTM Fig. 3-1, using a variable volume blower as a test air source, an orifice plate meter with an inclined manometer to measure leakage cfm and a manometer to measure duct static pressure.
5. Acceptable Results: Duct systems shall be tested, resealed and retested until acceptable results are obtained, eg. the measured leakage rate is equal to or less than the calculated permissible leakage rate.
6. Documentation: Duct system leakage testing results shall be recorded on forms which include the following information as a minimum:
 - a. Duct System Tested.
 - b. System Leakage Classification.
 - c. Duct System Square Footage.
 - d. Permissible Leakage Rate in CFM.
 - e. Duct Test Pressure.
 - f. Orifice Size.
 - g. Measured Pressure Differential.
 - h. Measured Leakage Rate in CFM.
 - i. Measured Duct Pressure.
 - j. Test Performed By.
 - k. Date/Time of Test.
 - l. Temperature and Weather Conditions of Test.
 - m. **[Engineer or Owners Representative Signoff.]**
7. Duct leakage test reporting forms shall be submitted to the Engineer for approval.

B. Leakage Classifications:

1. VAV Supply Ductwork Upstream of Terminal Units: Ductwork shall be tested to leakage Class **[6]** at **[+3"]** wg.
2. Supply Ductwork Downstream of Terminal Units: Ductwork shall be tested at leakage Class **[12]** at **[+2"]** wg.
3. Constant Volume Supply Air Ductwork: Ductwork shall be tested at leakage Class **[12]** at **[+2"]** wg.
4. Acoustic Supply Air Ductwork: Ductwork shall be tested at leakage Class **[6]** at **[+3"]** wg.
5. Outside Air Ductwork: Ductwork shall be tested at leakage Class **[6]** at **[+3"]** wg.
6. Garage Supply Ductwork: Ductwork shall be tested at leakage Class **[6]** at **[+4"]** wg.
7. Garage Exhaust Ductwork: Ductwork shall be tested at leakage Class **[6]** at **[-4"]** wg.
8. Stairwell Pressurization Ductwork: Ductwork shall be tested at leakage Class **[6]** at **[+3"]** wg.
9. **[Return Air Ductwork: Ductwork shall be tested at leakage Class **[12]** at **[-1"]** wg.]**
10. General Exhaust Ductwork: Ductwork shall be tested at leakage Class **[12]** at **[-2"]** wg.
11. Kitchen Exhaust Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[-3"]** wg.
12. Dishwasher Exhaust Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[-2"]** wg.
13. Smoke Exhaust Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[-3"]** wg.
14. Laboratory Hood Exhaust Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[-6"]** wg.
15. Underground Supply Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[+2"]** wg.
16. Underground Return Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[-2"]** wg.

END OF SECTION 23 31 13

SECTION 23 31 14 - DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide ductwork accessories as shown on the Drawings, specified and required.
- B. Types: The types of ductwork accessories required for the project include, but are not limited to:
 - 1. Flexible connections.
 - 2. Direction and volume control dampers.
 - 3. Fire dampers.
 - 4. Fire/smoke dampers.
 - 5. Smoke Dampers.
 - 6. Radiation dampers.
 - 7. Flashing and counterflashing.
 - 8. Turning vanes.
 - 9. Duct access doors and inspection plates.
 - 10. Test openings.
 - 11. Screens.
 - 12. Miscellaneous ductwork materials.

1.3 QUALITY ASSURANCE:

- A. SMACNA Compliance: Comply with applicable portions of Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) "HVAC Duct Construction Standards", current edition.
- B. ASHRAE Standards: Comply with American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.
- C. Certification: Fire, fire/smoke and smoke dampers shall be UL-listed, FM-approved and comply with applicable building code requirements.
- D. Manufacturers: Provide products complying with the specifications and produced by one of the following:
 - 1. American Foundry.
 - 2. Air Balance Inc.
 - 3. Duro-Dyne.
 - 4. Elgin Sheet Metal Products.
 - 5. Nailor Industries.
 - 6. Prefco.
 - 7. Ruskin.
 - 8. Tuttle and Bailey.
 - 9. United Sheet Metal.
 - 10. Vent-Fabrics, Inc.
 - 11. Ventlok.
 - 12. Young Regulator Co.

1.4 SUBMITTALS:

- A. Shop drawings submittals shall include, but not be limited to, the following:
 - 1. Cut sheets of ductwork accessories, clearly indicating materials, construction dimensions, ratings, approvals, and other pertinent information.
 - 2. Manufacturers' UL-approved installation instructions for fire, fire/smoke, and smoke dampers.
 - 3. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver ductwork accessories in factory-fabricated water-resistant wrapping.
- B. Handle ductwork accessories carefully to avoid damage to material component, enclosure and finish.
- C. Store ductwork accessories in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 DUCTWORK ACCESSORIES, MATERIALS, AND FABRICATION:

- A. General: Provide ductwork accessories which comply with Sections 15840, "Ductwork", and 15845, "Ductwork Accessories", for applicable product requirements of ductwork materials and as required for a complete ductwork system installation.

2.2 FLEXIBLE CONNECTIONS:

- A. General: Flexible connections shall be minimum 3" wide and be UL-labeled, 30 ounces glass fabric-lined with insulation and coated on both sides with neoprene, complete with attachment accessories, "Vent-Glass" by Vent-Fabrics, Inc., Elgen "Zipper-lock" HZ-LN-14, Duro-Dyne Excelon "Metal-Fab", flexible connections shall be fabricated in accordance with Fig. No. 2-19 of the SMACNA HVAC Duct Construction Standards, current edition, or approved equal.

2.3 DIRECTION AND VOLUME CONTROL DAMPERS:

- A. General: Provide all direction and balancing (volume control) 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 fabricated of steel not lighter than 16 gauge. The leading edge of the damper shall be hemmed. Each splitter shall be a minimum of 12" long or 1-1/2 times the width of the smaller of the two branches it controls, whichever is greater. Dampers shall be carefully fitted, and shall be controlled by locking quadrants equal to Ventlok No. 555 on exposed uninsulated ductwork, Ventlok No. 644 on exposed externally insulated ductwork and Ventlok No. 677 (2-5/8" diameter) chromium plated cover plate for concealed ductwork not above lay-in accessible ceilings, or approved equals. Furnish and install end bearings for the damper rods on the end opposite the quadrant when Ventlok No. 555 or No. 644 regulators are used, and on both ends when Ventlok No. 677 regulators are used. On concealed ductwork above lay-in accessible ceilings use Ventlok No. 555 or No. 644 locking quadrant for splitter dampers. Dampers larger than 3 square feet in area shall be controlled by means of rods hinged near the leading edge of the damper with provisions for firmly anchoring the rod and bearings supporting the axle.
 - 2. Balancing Dampers: Balancing dampers shall be provided in all zones of multi-zone air handling units, in all air device taps and where shown on the drawings. Refer to Section 233113 "Ductwork" for air device flexible duct taps. Balancing dampers shall consist of single blade dampers in rigid round duct and rectangular duct up to 10" high and 12" wide, and opposed blade dampers in ducts 11" high and larger. Single blade dampers shall be in accordance with Fig. 2-14 of the SMACNA HVAC Duct Construction Standards (SDCS), current edition, and opposed blade dampers shall be in accordance with SDCS Fig. No. 2-15. Single blade dampers for rectangular duct shall be Ruskin MD35 22 ga. single blade galvanized steel dampers or an approved equal. Single blade dampers for round duct shall be Ruskin MDRS35 20 ga. single blade galvanized steel dampers. Single blade dampers shall be provided with full length 3/8" square shafts secured to the damper blade with a minimum of 2 U-bolts, nylon bearings, insulation build out and heavy duty locking hand quadrants. Opposed blade dampers for

rectangular duct shall be Ruskin MD35/OB 16 ga. Galvanized steel opposed blade dampers or an approved equal. Opposed blade dampers shall be provided with full length 1/2" square shafts, concealed linkage, nylon bearings, insulation build out and heavy duty locking hand quadrants. Air pressure drop through each balancing damper not to exceed 0.05" wg at design airflow. All balancing dampers shall have 100% free area with damper open.

3. Damper Regulators: Damper regulators for concealed accessible applications shall be Young Valcalox 400 series lever handle damper quadrants or an approved equal. Where regulators are installed on externally insulated ductwork, provide stand-off platforms at least 1/4" higher than the insulation thickness. Where damper regulators are required in non-accessible locations, provide access doors or Young or equal extension rods, couplings, 90 degree gear drives, etc. as required and Young 301 or approved equal flush mounted remote regulator as directed by the Architect.
 4. Extractors: Provide extractors of the size and type indicated, with hex-key operated adjustable blades, with gang operated galvanized steel blades on one inch centers.
 5. Backdraft Dampers: Provide all aluminum gravity type backdraft dampers with an extruded frame and roll formed blades with silicon impregnated felt seals. Blade height shall not exceed 4", blade width shall not exceed 48" and blade linkage shall be provided to gang operate dampers by section.
- C. Operators: Damper operators for concealed inaccessible ductwork shall be Young Regulator Company, Catalog No. 700 or No. 315, as shown. Non-insulated accessible ductwork shall be Young Regulator Company, Catalog No. 433. Accessible insulated ductwork shall be Young Regulator Company, Catalog No. 443. Approved equal units by Duro-Dyne or Vent Fabrics, Inc. will be acceptable.

2.4 FIRE DAMPERS:

- A. General: Provide fire dampers at duct penetrations of rated floors, fire walls, elsewhere as shown in the Drawings and where required by **[City of Houston]** [] Building Code. Fire dampers shall comply with Uniform Building Code Standard No. 43-7, 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 shall be UL-labeled and shall meet all of the requirements of NFPA 90A and UL Standard 555.
1. Provide 1 hour rated dampers where penetrations are in required 1 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 excepted and shall not be penetrated by ductwork..
 4. Dampers shall be activated by a UL-approved fusible link which shall automatically close the damper upon operation. Fusible links shall operate at approximately 50°F above the maximum temperature in the duct system in normal operation, but not less than 165°F. All dampers associated with Life Safety Systems shall have minimum 212°F fusible links. Hinged dampers shall have stainless or cadmium-plated spring steel catches. All dampers shall be dynamic rated and shall have spring closure to ensure positive shutoff at velocities up to 5000 fpm and pressures up to 10" wg.
 5. Dampers shall be UL-rated per UL Standard 555 and shall be Ruskin Type DIBD Series, Style A, B or C, or an approved equal.
 6. Dampers shall be sized so that the free area space is not less than **[95%]** **[100%]** of the connected duct free area space for low velocity, low pressure ductwork and 100% of the connected duct free area space for high velocity, high pressure ductwork. Dampers shall be installed so as to provide a positive barrier to the passage of air when in the closed position. Dampers shall be installed with angle iron frames and slip joint connections per manufacturer's installation requirements and SMACNA Standards such that they are self-supporting in the case of duct destruction due to heat. The installing contractor shall be responsible for coordinating locations which require special sleeves.

7. Provide access doors as specified under ductwork for all internally actuated dampers. Where duct access doors are installed in non-accessible locations, provide ceiling or wall access doors. Label duct access doors "FIRE DAMPER ACCESS" with 1/2" high black stencil letters.

2.5 FIRE/SMOKE DAMPERS:

- A. General: Provide low leakage fire/smoke dampers at all locations shown on the Drawings or required. Dampers shall be multi-blade type combination fire/smoke dampers and shall possess a 1-1/2 hour UL label in accordance with UL 555S and shall meet all requirements of the latest edition of NFPA 90A and 101. Dampers shall be tested and certified in accordance with AMCA Standard 500-75 and shall leakage Class II per UL Standard 555S.
 1. Fire/smoke dampers and operators shall be UL-listed and labeled in the sizes used on the project and all dampers on the project shall be by the same manufacturer. UL-labeling of damper sizes used on the project shall be clearly indicated on shop drawing submittals.
 2. Dampers shall be suitable for opening and closing at static pressure up to 6" wg and at air velocities up to 3500 fpm. Damper leakage shall not exceed 10 cfm/sf at one inch wg or 200 cfm/sf at 4" wg.
 3. All combination fire/smoke dampers shall include an operating shaft which, when rotated, causes the damper to operate between open and closed. Operating shaft and damper combination shall be suitable for linking to and operation by any standard **[pneumatic] [electric]** damper operator having sufficient torque characteristics. Combination fire/smoke dampers shall be Ruskin Type FSD-60 or an approved equal with 212°F thermal links and rectangular, round or oval duct connections as required.
 4. Each combination fire/smoke damper shall be furnished complete with factory sleeve, damper operator, and thermal link factory-installed. The installing contractor shall be responsible for coordinating locations which require a special sleeve. Actuators shall be **[pneumatic] [electric]** type as specified or required and shall be of the spring fail closed type that will close upon loss of **[air supply] [power]**. Damper operators shall be UL-listed as fire damper operators, shall bear the appropriate UL fire damper operator label and shall be rated for continuous operation at 250°F.
 5. All pneumatic piping and controls to operate damper motors shall be furnished under **[Section 1230600, "Building Controls and Automation"**. **[All wiring and materials to interface the controls with the fire detection and alarm systems shall be furnished and installed under Division 26.]** Dampers shall be installed with angle iron frames and slip joint connections per manufacturer's recommendations and SMACNA Standards such that they are self-supporting in the case of duct destruction due to heat. Provide access doors as specified under Ductwork for all internally actuated dampers and for maintenance inspection of all externally actuated dampers. Where duct access doors are installed in non-accessible locations, provide ceiling or wall access doors. Label duct access doors "FIRE/SMOKE DAMPER ACCESS" with 1/2" high black stencil letters.
 6. **[A double pole double throw (DPDT) limit switch shall be provided factory-installed on each fire/smoke damper. The switch shall change position when the fire damper closes. Refer to Division 26 for wiring of limit switches.]**

2.6 SMOKE DAMPERS:

- A. General: Provide smoke dampers at all locations shown on the Drawings or required. Dampers shall meet all requirements for fire/smoke dampers except that the dampers shall not incorporate a thermal link feature.

2.7 RADIATION DAMPERS:

- A. General: Ceiling radiation type fire dampers shall be installed in all UL design assembly fired rated ceilings in strict accordance with manufacturers UL-listed installation instructions. Ceiling dampers shall conform to UL Standard 555 and shall be Ruskin Model #CFD5A or approved equal rectangular or round neck damper with a fusible volume adjustment link for up to 20" diameter round or up to 18" x 18" square neck T-bar 24 x 24 face lay-in diffuser with 1/2" thick ceramic insulation blanket for

diffuser pan. Air device pan shall be minimum of 24 gauge steel as required by UL. Thermal insulation blankets for radiation dampers shall be enclosed in an approved mesh material to allow easy handling of the blankets.

2.8 HIGH PRESSURE, LOW LEAKAGE, INDUSTRIAL CONTROL DAMPERS.

- A. **General:** Provide factory-fabricated all stainless steel construction opposed blade-type control dampers as shown on the Drawings or required by the Sequence of Operation specified in Section 230593. Dampers shall be provided by the Division 15 contractor for control by the control subcontractor.
- B. **Construction:** Dampers shall have stainless steel channel frames the full size of the duct or opening in which the damper is installed. Frames on dampers over 4 square feet shall have corner bracing. Damper frames shall be minimum 16 gauge formed stainless steel enclosed in a stainless steel round transition duct. Fabricate damper blades of not less than 16 gauge stainless steel with airfoil design. Damper blades shall have a maximum width of 6" and a maximum length of 48". All dampers shall be provided with stainless steel bearings, stainless steel jamb seals, and stainless steel hardware as standard. Axles shall be a minimum of 1/2" diameter and be locked to the blade with rivets or be welded. All blades on each damper section shall be interconnected to act in unison. Maximum leakage rate through a 48" x 48" closed damper shall not exceed 32.0 cfm per square foot of damper face area at 10.0" of water pressure differential and a maximum closing torque of 50 inches/ pounds. Damper leakage ratings shall be certified in accordance with AMCA Standard 500. Dampers shall be Ruskin CD30AF series low leakage control dampers or an approved equal and shall be rated for system pressures up to 10.0" wg for damper blades up to 48" wide.
- C. **Damper Sizing:** Two position dampers shall be full duct or louver size. Modulating dampers shall be sized according to approach velocities, pressure drops, and similar criteria to obtain linearized characteristics. Maximum approach velocity shall be 1500 feet/ minute. Damper free area shall be sized by the BCAS manufacturer. Provide necessary blankoff plates between damper leaves to obtain the required free area. Damper sizing shall be submitted to the Engineer for approval.
- D. **Operating Temperature Range:** Range shall be from -40°F to 180°F.
- E. **Operating Linkage:** Linkage shall be factory-assembled and shall be capable of withstanding a load equal to twice the maximum operating force of the damper operator without deflection.

2.9 AUTOMATIC MANIFOLD BLEED DAMPERS:

- A. Provide heavy duty round butterfly or opposed blade control dampers as shown on the drawings and required by the Sequence of Operation specified in Section 230593. The Division 15 contractor shall provide dampers for control by the control subcontractor.
- B. Dampers shall be 316 stainless steel construction. Dampers shall be butterfly type consisting of circular blade, mounted to axle within formed flanged frame. Frame shall be constructed of steel channel and shall have full circumference blade stop located in air stream. Damper shaft shall be continuous, solid cold rolled steel extending through entire diameter of damper and beyond damper bearing a minimum of 6 inches. Axle shall be supported in sealed, relubricable ball bearings mounted to damper frame. Damper frame and blade shall be fabricated from hot rolled steel. Damper frame shall be minimum 10 gauge. Damper flanges shall be minimum 1 1/2" wide. Provide bolt holes in both flanges. Minimum blade thickness shall be 1/4". Axle diameter shall be minimum 3/4". Dampers shall be Ruskin model CDR92 or approved equal. At the contractor's option these dampers may be rectangular opposed blade dampers.

2.10 FLASHING AND COUNTERFLASHING:

- A. General: Flashing and counterflashing shall be as specified in other Divisions of these Specifications.

2.11 TURNING VANES:

- A. General: Provide turning vanes in the size and type indicated with the following additional construction features:
 - 1. Blades: 2" galvanized steel for up to and including 18" ducts.
 - 2. Blades: 4-1/2" galvanized steel for ducts over 18".

3. Construction: Single wall blade, constructed in accordance with Fig. No. 2-3 and Fig. No. 2-4 of the SMACNA HVAC Duct Construction Standards, current edition.
4. Types: Fixed blades for 90 degree elbows, adjustable for transition elbows and fixed for 45 degree elbows where shown.

2.12 DUCT ACCESS DOORS AND INSPECTION PLATES:

- A. Access Doors: Provide [**Flexmaster Inspector Series Spin-In low leakage, round, high pressure, dual wall, insulated**][**Ruskin Type ADH2, Flexmaster Inspector Series Tab Doors or approved equal dual wall, insulated, hinged**] access doors in ductwork as required for access to fire, smoke and fire/smoke dampers, duct smoke detectors, sampling tubes, humidifiers and other duct mounted devices. Minimum door size shall be [**12" round**][**14" x 14"**] unless a smaller size is required due to duct dimensions. Square access doors shall be constructed in accordance with Fig. No. 2-12 and 2-13 of the SMACNA HVAC Duct Construction Standards, current edition.
- B. Inspection Plates: Provide inspection plates where shown on the Drawings. If not detailed, 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 sheet metal screws.

2.13 TEST OPENINGS:

- A. General: Ventlok No. 699 instrument test holes in locations as required to measure pressure drops across each item in the system, e.g., O.A. louvers, filters, fans, coils, intermediate points in duct runs, etc. Test holes in stainless steel duct systems shall be 316 stainless steel or an approved corrosion resistant design.

2.14 SCREENS:

- A. General: Provide screens on all duct, fan, etc., openings furnished by this Contractor which lead to, or are, outdoors. Screens shall be No. 16 gauge, 1/2" galvanized steel mesh in removable galvanized steel frame. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

2.15 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.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Flexible Connections: Install flexible connections where ducts connect to fans, including roof exhausters. There shall be a minimum of 1/2" slack in the connections, and a minimum of 2-1/2" distance between the edges of the ducts except that there shall also be a minimum of one inch (1") of slack for each inch of static pressure on the fan system.
- B. Dampers: Install balancing, splitter and backdraft dampers where shown on the Drawings and wherever necessary for complete control of the airflow, including all supply, return and exhaust branches, "division" in main supply, return and general exhaust ducts, each individual air supply outlet and fresh air ducts. Where access to dampers through a fixed suspended ceiling is necessary, this Contractor shall be responsible for the proper location of the access doors. Install balancing dampers in each zone of multi-zone units.
- C. Fire, Fire/Smoke and Smoke Dampers: Install fire, fire/smoke and smoke dampers as detailed on the Drawings and in strict accordance with the damper manufacturers UL-approved installation instructions.
- D. Flashing: Install flashing where ducts pass through roofs or exterior walls, suitable flashing shall be provided to prevent rain or air currents from entering the building. The flashing shall be of not less than No. 24 gauge 316 stainless steel.
- E. Turning Vanes: Install turning vanes per SMACNA standards. Turning vanes in ducts carrying air under pressure of 1-1/2" water gauge or more shall be anchored to the cheeks of the elbow in such a

way that the cheeks will not breathe at the surfaces where the vanes touch the cheeks. In most cases, this will necessitate the installation of an angle iron support on the outside of the cheek parallel to the line of the turning vanes.

- F. 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 City Code Requirements and NFPA 96. Install hinged access doors in ductwork to provide access to all fire dampers, mixed air plenums, upstream of steam reheat coils, automatic dampers, etc. Where the ducts are insulated, the access doors shall be double skin doors with one inch of insulation in the door. Where access doors are located above a suspended ceiling, this Contractor shall be responsible for the proper location of the ceiling access doors, if the ceiling system does not provide proper access.
- G. Inspection Plates: Install plates at each multi-zone zone damper and where otherwise indicated on the Plans.
- H. Test Openings: Install test openings for pitot transverse of all supply, return, and exhaust duct connections to fan powered equipment, at each duct mounted balancing damper and at other locations required for proper measurement of airflow in all duct systems.

3.2 TESTING:

- A. General: Check installed ductwork accessories for required operation and leakproof performance during the system's operational test. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.
- B. Damper Testing: Test all fire, fire/smoke and smoke dampers for proper operation after the damper installation is complete. Dampers which exhibit any binding or other forms of impaired operation shall be replaced and retested. Refer to Section 23 05 93 for additional requirements.
- C. Damper Certification: The Contractor shall include in the Operating and Maintenance Manuals, a letter certifying that all fire, fire/smoke and smoke dampers have been tested and are fully operational. Refer to Section 23 05 93 for additional requirements.

END OF SECTION 23 31 14

SECTION 23 33 19 - SOUND ISOLATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide sound isolation work as specified, scheduled, and shown on the Drawings.
- B. Types: The types of sound isolation required for the project include, but are not limited to, duct sound attenuators for use in duct and return air applications.

1.3 QUALITY ASSURANCE:

- A. Manufacturers: Provide sound isolation units complying with these specifications and produced by one of the following:
 - 1. Industrial Acoustics Company.
 - 2. Koppers Company, Inc.
 - 3. Peabody Noise Control.
 - 4. Rink Corporation.

1.4 SUBMITTALS:

- A. Shop Drawing submittals shall include, but are not limited to, the following:
 - 1. Cut sheets clearly indicating the size, type, ratings, insertion loss, regenerated noise, materials, construction, connection types, performance and other pertinent data for each sound attenuator to be provided on the project.
 - 2. Independent test laboratory reports on performance of each silencer type being provided.
 - 3. Additional information as required in Section 23 01 00.

1.5 PRODUCT, DELIVERY, STORAGE AND HANDLING:

- A. Deliver sound attenuators in factory-fabricated water-resistant wrapping.
- B. Handle sound attenuators carefully to avoid damage to material components, enclosure and finish.
- C. Store sound attenuators in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 DUCT SOUND ATTENUATORS:

- A. General: Provide duct sound attenuators of the size and capacity scheduled or shown on the Drawings and having dynamic insertion losses and static pressure losses equivalent to those scheduled.
- B. Construction: Sound attenuators shall have outer casings constructed of not less than 22 gauge galvanized steel in accordance with SMACNA and ASHRAE recommended construction for high pressure ductwork. All seams shall be lock-formed and sealed airtight. Internal panels shall be of not less than 26 gauge galvanized perforated steel corrugated in direction of airflow. Internal passages shall be essentially straight through with consistently exact dimensions to ensure uniform performance. All internal parts shall be fastened by spot-welding on not more than 3" centers. Sheet metal screws, bolts, or other mechanical fasteners will not be allowed. Fill lock-formed seams with mastic. Units shall be airtight at a differential air pressure of 8" water gauge.
- C. Filler: Acoustical filler material shall be in organic mineral or glass fiber of a density sufficient to obtain the scheduled acoustical performance and shall be packaged under a minimum 5% compression to eliminate voids. Filter shall be inert and vermin and moistureproof.

- D. Combustion Rating: Maximum combustion ratings shall be flame spread, classification of 20, smoke developed rating of 20 and a fuel contribution of 20 when tested in accordance with ASTM E84, NFPA 255, and UL 723.
- E. Acoustic Performance: Silencer ratings shall be determined in a duct-to-reverberant room test facility which provided for airflow in both directions through the test silencer in accordance with ASTM E477. The test set-up and procedure shall be such that all effects due to end reflection, directivity, flanking transmission, standing waves, and test chamber sound absorption are eliminated. Acoustic ratings shall include Dynamic Insertion Loss (DIL) and Self-Noise (SN) Power Levels both for forward flow (air and noise in same direction) and reverse flow (air and noise in opposite directions) with airflow of at least 2000 fpm entering face velocity. Data for rectangular and tubular type silencers shall be presented for tests conducted using silencers no smaller than 24" x 24", 24" x 30", or 24" x 36" cross sections.
1. The manufacturer shall submit certified test data on dynamic insertion loss, self-noise power levels, and aerodynamic performance for reverse and forward flow test conditions. Test data shall be for a standard product. All rating tests shall be conducted in a single independent facility and shall utilize the same silencer.
 2. Acoustical testing shall be determined by the "duct to a reverberation room" method, as recommended by SIW 42 Subcommittee of the American National Standards Institute. Tests shall be run with air flowing through the silencer at not less than three different flow rates and also at zero flow. All ratings shall be based on test data from a nationally known qualified independent laboratory. Test methods shall eliminate effects due to end reflection vibration flaring transmission and standing waves in the reverberant room. Airflow and pressure loss data taken in accordance with the AMCA procedures shall be obtained from the same silencer used for acoustical performance test.
- F. Aerodynamic Performance: Static pressure loss of silencers shall not exceed those listed in the silencer schedule at the airflow scheduled. Airflow measurements shall be made in accordance with ASTM E477 and applicable portions of ASME, AMCA, and ADC airflow test codes. Tests shall be reported on the identical units for which acoustic data is presented.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install sound attenuators in accordance with the manufacturers written installation instructions and appropriate SMACNA standards.
- B. Supports: Sound attenuators shall be supported as specified for ductwork, except that each attenuator shall be independently supported at each corner.
- C. Transitions: Provide inlet and outlet transitions at duct sound attenuators with 15 degree angles where space permits, but in no case with more than 30 degree angles on the inlet side and 45 degree angles on the outlet side.

END OF SECTION 23 33 19

SECTION 23 34 43 – LABORATORY HIGH PLUME EXHAUST FANS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install the following fans and components indicated by the Contract Documents with supplementary items necessary for proper installation.
 - 1. Airfoil centrifugal wheel fans.
 - 2. Backward inclined / backward curved centrifugal wheel fans.
 - 3. Axial / backward curved mixed flow impeller bifurcated fans.
 - 4. Motors and drives.
 - 5. Fan accessories.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AMCA 99 - Standards Handbook.
 - 2. AMCA Publication 111 - Laboratory Accreditation Program.
 - 3. ANSI/AMCA Standard 210 - Laboratory Methods of Testing Fans for Rating.
 - 4. AMCA Publication 211 - Certified Ratings Program - Product Rating Manual for Fan Air Performance.
 - 5. AMCA Standard 260 - Laboratory method of Testing Induced Flow Fans for Rating.
 - 6. AMCA Standard 300 - Reverberant Room Method for Sound Testing of Fans.
 - 7. AMCA Publication 311 - Certified Ratings Program - Product Rating Manual. For Fan Sound Performance.
 - 8. AMBA - Method of Evaluating Load Ratings of Bearings ANSI-11.
 - 9. ANSI/AMCA Standard 204 - Balance Quality and Vibration Levels for Fans.
 - 10. AMCA Standard 500-D-98 - Laboratory Methods of Testing Dampers For Rating.

11. AMCA Standard 500-L-99 - Laboratory Methods of Testing Louvers For Rating.
12. SMACNA - Medium Pressure Plenum Construction Standard.
13. ANSI Z9.5 – Laboratory Design.

1.04 QUALITY ASSURANCE

- A. The following quality assurance requirements apply to all fans described and furnished under this Section:
1. Performance ratings: Conform to AMCA Standard 211 and 311. Fans must be tested in accordance with AMCA 210, 260 and 300 in an AMCA accredited laboratory and the high plume exhaust fan shall be licensed to bear the AMCA seal for Certified Sound and Air Performance. Acceptable manufacturers whose equipment is not licensed to bear the AMCA seal for Certified Sound and Air Performance must submit air and sound performance tests conducted by an independent third party, and stamped by a registered professional engineer.
 2. Fans designated or classified for Type C Spark Resistant Construction must conform to AMCA 99 requirements.
 3. Each assembled fan shall be test run at the factory at the specified fan rpm with CFM per watt, and vibration signatures shall be recorded and documented. Vibration signatures are to be measured at each bearing location in the horizontal, vertical, and axial planes. The maximum allowable fan vibration shall not be greater than 0.08 inches per second at the peak velocity; filter-in reading as measured at the fan rpm. The report with documented test results shall be included with the shipment for each fan.
 4. The manufacturer shall also provide, at the Owner and Engineer's option, witness testing of fan inlet tests measured in an AMCA accredited laboratory (AMCA Publication 111-99), in accordance with AMCA 210. Witness fan discharge and entrainment airflow, using a modified AMCA 210 test set up where the fan inlet is placed in the open and the fan outlet (which includes the induction stack) is connected to the airflow test apparatus. This total fan outlet airflow test shall verify the entrainment airflow rate, which is the dilution performance by subtracting the measured fan inlet airflow rate from the fan outlet airflow rate. This performance test shall be performed as part of the product submittal phase of the Project.
 - a. [Engineer must provide minimum plume heights, laboratory design air flow rates, static pressure requirements, and maximum motor horsepower requirements for high plume exhaust fans on equipment schedules.]
 5. Minimum design airflow rates, static pressure, and plume heights as referenced on the Drawings.
 - a. The scheduled minimum plume height shall be accomplished at the scheduled design airflow rate and analytically established from ASHRAE Laboratory Design Guide, Equation 9-2.
 - b. The plume height shall be visually indicated by inducing smoke at the fan inlet and also at the air inlet side of the induction ring.
 - c. The vertical plume height is determined and measured where the diluted smoke no longer continues a vertical path parallel with the centerline fan outlet or induction ring nozzle.

1.05 SUBMITTALS

A. Product Data:

1. Submit data for approval for all fans of every description furnished under this Section.
 - a. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gages or thickness, finishes of materials, electrical characteristics, and connection requirements for each model of high-plume dilution laboratory exhaust fan assemblies being provided for the Project.
 - b. Fans shall be capable of operating stably at reduced capacities imposed by means of a variable frequency drive.
 - c. Product test data on sound power levels for both fan inlet and outlet at the rated design capacity.
 - d. Product data on special coatings and construction where applicable.
 - e. Product data on all fan accessories.
 - f. Provide fan curves for each fan at the specified operation point, with the flow, static pressure and horsepower clearly plotted. The recommended operating range where the fan will remain stable.
 - 1) [Engineer must provide wind velocity 1 percent of the time as listed Chapter 26 in Tables 1A, 2A, and 3A of ASHRAE Handbook – Fundamentals for many cities. For cities not listed the wind speed is 2.5 times the annual average hourly wind speed as recommended in Table 2, Chapter 15 of the ASHRAE Handbook – Fundamentals.]
 - g. Provide nozzle velocity of exhaust fan, total exhaust flow, and results of the effective discharge plume height based on the specified wind velocity of [____].
 - h. Strictly adhere to Quality Assurance requirements as stated in this Section.

B. Operation and Maintenance Data:

1. Manufacturer's installation instructions and operating and maintenance data.
 - a. Submit under provisions of Division 01.
 - b. Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to the Project Site under provisions of Division 01 and Division 20.
- B. Accept products on Site in factory-fabricated protective containers or coverings, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

- D. Check and maintain equipment on a monthly basis to ensure equipment is being stored in accordance with manufacturer's recommended practices. Additionally, during each check, fans and motors shall be rotated and greased and shafts shall be left approximately 180 degrees from that of previous month. Maintain storage records that indicate these maintenance requirements have been met.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Base fan performance at standard conditions (density 0.075 Lb/ft³).
- C. Fans shall be capable of accommodating static pressure and flow variations of +/-15 percent of scheduled values.
- D. The completely assembled fan shall be tested to meet the vibration limits as published in AMCA 204.
- E. Equip each fan with fan inlet isolation damper to prevent the fan from turning in reverse rotation when the fan is off.
- F. Equip fans with stainless steel lifting lugs for corrosion resistance.
- G. When a powder coating process is used on fan and plenum, the coating shall be minimum thickness of 3 mils. Finish color shall be light gray.
- H. Fasteners exposed to corrosive exhaust shall be Type 304 or Type 316 stainless steel.
- I. Fan assembly shall be designed for a minimum of 125-mph side wind loading, without the use of guide wires.

2.02 MANUFACTURERS

- A. High Plume Dilution Blowers:
 - 1. Greenheck Fan Corporation, Model Vektor MD or CD Direct / Belt Drive.
- B. High Plume Exhaust Systems:
 - 1. M.K. Plastics Corporation, Model Axijet Direct / Belt Drive.
- C. Laboratory Exhaust Systems:
 - 1. Strobic Air Corporation, Model Tri-Stack Direct Drive.

2.03 CENTRIFUGAL HIGH PLUME EXHAUST FANS

- A. Fans shall be configured as belt driven per AMCA Arrangement 1, 9, 10 or direct drive per AMCA arrangement 8 according to the Drawings. Fans mounted on top of exhaust air plenums or are not accessible from the roof shall be equipped with jib cranes (complete with removal hoist), for motor maintenance and removal.
- B. Fan, plenum and dampers shall be coated with a minimum of 3 mils of Plastifer epoxy ES90-AS81, or Hi-Pro Polyester resin coatings. Finish color shall be light gray.

- C. Fan assemblies that use flexible connectors that can fail and cause loss of laboratory containment are not acceptable. Inlet elbow/plenum shall be attached to the fan inlet by a high strength, corrosion resistant flexible connector, or vibration isolation pad or gasket, provided by the fan manufacturer.

2.04 MIXED FLOW HIGH PLUME EXHAUST FANS

- A. Mixed flow steel case fans shall be direct driven in AMCA Arrangements 2, or AMCA Arrangement 4, or belt driven in AMCA Arrangement 9. Fans systems shall be equipped with jib crane (complete with removal hoist), for motor maintenance and removal.
- B. Fan, plenum and dampers shall be coated with a minimum of 4-6 mils of Plastifer epoxy ES90-AS81, Hi-Pro Polyester resin or Amercoat 90HS Epoxy-phenolic coatings. Finish color shall be light gray.

2.05 FAN HOUSINGS AND OUTLET

- A. Fan housings shall be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
- B. Steel fan housings shall be centrifugal involute scroll, allowing all drive components including the motor to be serviced without contact of the contaminated air stream, and manufactured of welded steel coated with a minimum of 3 mils of Hi-Pro Polyester resin, electrostatically applied and baked. Finish color shall be gray. No uncoated metal fan parts exposed to the exhaust will be acceptable.
- C. Fiberglass reinforced plastic (FRP) fan housings shall be manufactured in specifically formulated resins, for maximum corrosion resistance, UV inhibited and reinforced with fiberglass for structural strength. Fastening bolts holding the casing to the support plate are to be encapsulated in FRP. Finish color shall be light gray. Fan to be supplied with a graphite liner and grounding strap to remove static electricity, as well as a flame retardancy of 25 or less, if required. Fiberglass reinforced plastic fan housings that are fabricated shall have mechanical strength and toughness properties equivalent to steel housings, interior surfaces shall be smooth to assure corrosive or hazardous compounds can not collect, and / or chalk and structurally degrade. Having smooth interior surfaces will also reduce collection of biological contaminants.
- D. Centrifugal fans shall be equipped with access doors shaped to conform to the housing scroll with quick opening latches and gaskets.
- E. A steel or fiberglass reinforced plastic discharge nozzle shall be supplied by the fan manufacturer, and shall be designed to efficiently handle an outlet velocity of up to 7000 FPM. The discharge nozzle shall include either bifurcated section or a discharge section surrounded with a wind band to induce ambient air.
- F. A drain shall be designed as an integral part of the centrifugal fan housing to drain rainwater when the fan is de-energized.
- G. Supply a bolted and gasketed access door for impeller inspection and service.
- H. Fan assembly shall be AMCA type C spark resistant construction minimum or as noted on the Drawings.

2.06 FAN IMPELLERS

- A. Centrifugal Type:

1. Fan impeller for centrifugal fans shall use backward inclined or airfoil blade design wheel with non-stall characteristics. The impeller for either wheel design shall be electronically balanced both statically and dynamically meeting or exceeding Grade 6.3 per AMCA Standards.
 2. Fan impeller shall be manufactured of welded and coated steel with a minimum of 3 mils of Hi-Pro Polyester resin, or 4-6 mils of Plastifer epoxy ES90-AS81 with a finish color of light gray.
- B. Mixed Flow Type:
1. Fan impeller for vertical inline fan shall use a combination axial / backward curve blade design wheel with non-stall characteristics. Stationary discharge guide vanes located above the impeller shall be provided to increase fan efficiencies. The impeller for either wheel design shall be electronically balanced both statically and dynamically meeting or exceeding Grade 6.3 per AMCA Standards.
- C. Fan impeller shall be manufactured of welded and coated steel with a minimum of 3 mils of baked Hi-Pro Polyester resin or 4 mils Epoxy-phenolic coatings. Finish color shall be light gray.

2.07 EXHAUST AIR PLENUM CURBS

- A. For a constant volume exhaust system, the fan / nozzle assembly shall be connected directly to roof or roof curb and exhaust duct without need for a bypass air plenum.
- B. For a variable volume exhaust system, a bypass air plenum shall be provided as shown on Drawings. The plenum shall be provided with stainless steel modulating opposed blade bypass air damper(s) for introducing outside air at roof level upstream of the fan, complete with bypass air rain hood and bird screen. The actuator(s) to operate the bypass damper are to be supplied by the building automation system (BAS) Provider.
- C. A parallel blade fan tight shutoff isolation damper, two position actuated, fabricated of stainless steel, shall be provided as shown on the Project documents. Isolation damper shall include a factory mounted and wired actuator; complete with a mounted and wired step down transformer, wired to the fan disconnect. Transformer shall be mounted in a NEMA 3R panel, minimum, or as shown on the Drawings. The isolation damper precludes reverse rotation of the fan wheel when the fan is not energized.
- D. The plenum shall be constructed of welded cold rolled steel, and coated with minimum 3 mils of Hi-Pro Polyester resin or Epoxy-phenolic coatings.
- E. Plenums that are fabricated of plastics or resin that are combustible and have mechanical properties less than steel shall not be acceptable.
- F. The bypass air plenum shall be mounted on factory fabricated roof curb provided by the fan manufacturer, as shown on the Drawings
- G. Fan designs that use inlet flexible connectors that can leak causing loss of lab exhaust shall not be permitted.
- H. Blower / Plenum vibration isolation shall be limited to neoprene / cork vibration pads.
- I. Exhaust system manufacturer shall supply a structural support curb for the plenum, of specified height, as shown on the Drawings.
- J. Curb shall be fabricated of a minimum of 12 gage corrosion resistant coated steel and structurally reinforced.

- K. Vertical exhaust inlet plenums shall have curbs that are insulated. Horizontal exhaust inlet plenums shall have un-insulated plenums.
- L. The plenum shall have integral drain connections to drain water that may condense on the inner wall of the plenum.
- M. When properly anchored to the roof structure, the standard curb / plenum / blower assembly shall withstand wind loads of up to 125 mph without additional structural support.

2.08 FAN MOTORS AND DRIVES

- A. Motors shall be premium efficiency, standard NEMA frame, 900, 1200, or 1800 rpm, TEFC, and compatible with variable frequency drives as scheduled. Refer to Section 20 05 13. Provide a factory mounted NEMA 3R disconnect switch, mounted and wired, for each fan.
- B. Direct drive arrangement shall be AMCA Arrangement #2, utilizing a direct mount coupling connecting the motor shaft and fan impeller shaft. Exhaust fan systems with direct drive Arrangement #4 where the fan wheel is connected directly to the shaft of the motor, will require a tight shut-off isolation damper at the fan inlet to allow the fan to be removed for motor replacement. Fan shaft shall be Type 316 stainless steel.
- C. Belt drive arrangement shall be AMCA Arrangement 1, 9, 10. Drive belts and sheaves shall be sized for 200 percent of the fan operating brake horsepower, and shall be readily and easily accessible for service. Fan shaft shall be 316 stainless steel or ANSI C-1045 steel and be protected with TECTYL protective coating. If the fan is not scheduled to be operating in conjunction with a variable frequency drive, then include an additional set of drives for each fan to be used for final adjustments. After correct speed has been determined with variable sheave, provide fixed sheaves.
- D. Belt Guard: All belt drives shall be furnished with belt guards. Fabricate to SMACNA Low Pressure Duct Construction Standards; of 12 gage 3/4-inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
- E. Fan shaft bearing(s) shall have a key-way, and shall be milled and machine polished, Type 316 stainless steel.
- F. Mechanical shaft seals are to be either neoprene or Teflon (but only when required).
- G. Fan shaft bearings shall be ball or roller pillow block type and be sized for a requirement of L-10 life of no less than 200,000 hours. Bearing(s) shall have extended lube injection lines Zerk grease fittings and lube relief lines with caps.
- H. Motor, coupling, and bearing shall all be outside the contaminated exhaust air pathway.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. Install fan systems in accordance with manufacturer's instructions and Contract Documents. Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings are lubricated, and the fan has been test run under observation.
- C. Install fans with resilient mountings and flexible electrical leads. Refer to Section 20 05 48.

- D. Install flexible connections specified in Section 23 33 00 between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one-inch flex between ductwork and fan while running.
- E. Install fan restraining snubbers as required. Refer to Section 20 05 48. Adjust snubbers to prevent tension in flexible connectors when fan is operating
- F. Pipe centrifugal fan housing and / or plenum drain to the nearest drain.

3.02 PAINTING

- A. Provide fans with factory finish in accordance with the manufacturer's standard. Touch up scratches and marks from handling and placement of equipment with masking enamel to match manufacturer's color.
- B. Where exhaust fans are required to have polyester, epoxy or Heresite coating, have units factory finished with required number of coats prior to shipping to the Project Site.
- C. Refer to Division 09 for Site-applied finishes.

END OF SECTION 23 34 43

SECTION 23 36 00 - HVAC TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: HVAC terminal units shall include, but not be limited to:
 1. Fan powered terminal units.
 2. Single duct VAV air valve terminal units.
 3. Double duct terminal units.

1.3 QUALITY ASSURANCE:

- A. Basis of Design: The following manufacturer models have been tested and found to comply with both the performance and design specifications that follow. These tests and inspections were performed to verify the availability of equipment that is in compliance with these Specifications when properly selected.
 1. Titus **[QFPC] [MFV] [MFC] [FPC]** Series selected at medium speed for fan powered mixing boxes.
 2. Titus ESV-3000 Series for VAV air valves.
 3. Titus **[EDV-3100] [EDC-3100]** Series for double duct terminal units.
- B. Manufacturers: Terminal units from Nailor, Krueger, Enviro-Tec,
- C. Price, or Metalaire may be acceptable where documented independent test results and equipment submittals are reviewed by the Engineer to verify specification compliance.
- D. Certification: Provide manufacturer's and independent test lab certification of test results, signed by an authorized officer of the company.
- E. Preparation: HVAC terminal units to be clean and free of all foreign matter prior to shipping. Units and associated equipment such as controls, shall be packaged in a manner to prevent dust and other foreign matter from entering the unit, controls, and similar items during shipment. All external controls, operators, and sensors shall be covered by rigid metal shields during shipment and storage.

1.4 SUBMITTALS:

- A. Shop drawing submittals shall include, but not be limited to, the following:
 1. Cut sheets on each terminal unit, clearly marked to show sizes, configuration, construction, unique features, controls, clearances, accessories, performance data, sound data, operating sequence and other pertinent information.
 2. Air valve **[and fan]** curves or charts which clearly show air valve **[and fan]** performance.
 3. Performance characteristics for each terminal unit.
 4. Wiring and control diagrams and air flow sensor calibration curves for each terminal unit type.
 5. Copies of factory-certified sound, leakage and performance test results from actual tests of units of the same model and construction to those which will be provided for the project.
 6. Written report of the test results including noise criteria (NC) in sound power as tested in **[an independent test lab]** reverberant room with terminal unit operating at the scheduled airflow. When reporting NC levels, no credits or reduction shall in any way be considered for room, plenum, ceiling, and similar item effects.
 7. Certified dimensioned drawings showing the locations of all openings, support points, connections, sizes for same, overall dimensions of all boxes and any other pertinent information that may affect the installation of the boxes.

8. Submit the following certified performance data for each size and type of terminal unit to be used on the project:
 - a. Maximum and minimum cfm ratings at 0.35" discharge static pressure.
 - b. Fan horsepower and cfm curves for each fan (fan powered terminal units only).
 - c. Pressure drop through each primary air damper at 25%, 50% and 100% of design cfm.
 - d. Pressure drop through terminal unit and heating coil at full plenum air mode for fan powered terminal units and full heating and full cooling modes as applicable for single and double duct terminal units.
 - e. Radiated and discharge sound power data for each size terminal unit at 0.5", 1.0", and 1.5" primary duct static pressure, 0%, 25%, 50%, 75% and 100% primary cold air and design discharge cfm (constant fan powered terminal units only) and static pressure.
 - f. Temperature mixing data for each size fan powered or dual duct terminal unit at maximum and minimum discharge cfm for the unit size with 25%, 50% and 75% primary air.
9. Product warranties and guarantees.
10. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver HVAC terminal units in factory-fabricated water resistant packaging.
- B. Handle HVAC terminal units carefully to avoid damage to components, enclosures, and finish.
- C. Store HVAC terminal units in a clean, dry space and protect from weather.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. General: Provide HVAC 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.

2.2 FAN POWERED TERMINAL UNITS:

- A. General: Provide **[constant] [variable]** volume, pressure independent **[constant] [intermittant]** fan-powered terminal units consisting of a sheet metal housing with a control damper, damper operator, fan assembly, heating coil (where scheduled), and flow controls. Fan powered terminal units shall be compatible with the temperature controls as specified in **[Section 15900, "Building Controls"] [Division 17]**. Terminal unit capacities and sizes shall be as scheduled and shown on the Drawings.
- B. Housing: Shall be constructed of 20 gauge minimum galvanized sheet metal with a rigid frame with mechanical seals and gaskets to minimize housing leakage. Housing shall be lined with one inch (1"), dual density fiberglass. Insulation shall meet the requirements of NFPA 90A and UL 181 **[and be protected with a perforated steel inner liner [on Size 7 terminal units]]**. **[Housing shall be designed such that both cold air and plenum air are equally split between both sides of the double inlet unit fan.]** Gasketed access doors **[with a maximum of four speed latches]** shall be provided on the bottom of each unit. Housing shall be provided with a round or oval inlet for use with flexible duct (1800 fpm maximum velocity) and a rectangular outlet for slip and drive connection to sheet metal ductwork (1600 fpm maximum velocity).
- C. Control Damper: Shall be of a low leakage, **[sliding plate "zebra" design with stainless steel plates and] [opposed blade or] [single blade design with]** self-lubricated bearings. Dampers shall be suitable for use with **[pneumatic] [electric]** operators.
- D. Damper Operators: Shall be a **[pneumatic] [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 **[piped] [wired]** including all controls required for operation, except **[main air and thermostat] [control wiring]** connections. Operator**[s] [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.

- E. **Fans:** Provide fans balanced statically and dynamically, of the indicated capacity, designed and assembled to be easily removed for servicing. **[Fans shall move design airflow at all times of box operation.]** Fans shall be of metal construction. Provide centrifugal fan wheels designed for discharge static pressures indicated on the Drawings. System shall be nonoverload. Provide vibration isolation as required.
- F. **Motors:** Provide motors of the indicated or required capacity, installed for easy removal, with automatic reset thermal overload protection of the 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.
- G. **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. 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.

[INCLUDE FOR INTERMITTANT FAN UNITS ONLY]

- H. **[Backdraft Damper:** Fan backdraft damper shall be a low noise, low leakage type with aluminum blades and blade seals.]

[SELECT ONE OF THE FOLLOWING]

- I. **[Electric Heating Coils:** Electric heating coils shall be provided on fan powered terminal units where scheduled or shown on the Drawings. 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. 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 [a pneumatic heater control switch (PE switch)] [electronic controls] for each heater contactor.]

[OR]

- J. **[Hot Water Heating Coils:** Hot water heating coils shall be provided on fan powered terminal units, where scheduled or shown on the Drawings. Hot water heating coils shall be constructed with 0.010" aluminum plate fin with collars drawn, belled and firmly bonded to 1/2" diameter [0.020"] [0.035"] wall copper tubes. Coil headers shall be brass or bronze. No soldering or tinning shall be used in the bonding process. Coils shall have galvanized steel casing and [manual] [automatic] air vents. Coil header and U-bends shall be insulated and shall not be exposed. Coils shall be provided with automatic air vents and drain valves. Factory test coils with 300 psig air pressure under water. Coil face velocity shall not exceed 700 fpm. Coils shall have a maximum of 12 fins per inch. Coil air and water pressure drops shall not exceed scheduled maximums.]

[INCLUDE FOR HOT WATER COILS ONLY]

- K. **[Hot Water Coil Valves: Valves shall be electrically-operated and shall be furnished and installed under [Section 23 06 00 "Building Control and Automation Temperature Controls"], [shall be electrically-operated and shall be furnished, and wired with the terminal unit.]**

[VERIFY PROJECT REQUIREMENTS]

- L. **Leakage:** Overall leakage for the control damper and pressurized portions of the housing shall be less than 3% of nominal cfm at **[3"] [6"]** inlet SP and scheduled outlet SP, as rated by ARI 880 (latest Edition).
- M. **Controls:** Fans, pressure independent volume controls and heater controls shall be factory-installed, including a multipoint air flow sensor for inlet air volume measurement, **[a Titus II Flow Logic Analyzer or equal, an adjustable fan control PE Switch [, adjustable heater stage PE switches]] [a DDC terminal unit controller, fan contactor [, heater stage contactors]]** and related accessories and components. Controls shall provide adjustable minimum and maximum cfm limits, adjustable throttling range and a constant throttling range option. Adjustments for control settings and gauge tees for flow measurement and balancing shall be easily accessible. **[DDC controllers and damper operators shall be furnished by the [Temperature Control] [Division 23 BCAS] Contractor for factory installation, wiring and testing by the terminal unit manufacturer.]** Fan **[and heater] contactors [and PE switches]** shall be provided by the terminal unit manufacturer. Coordinate control voltages with the **[Temperature Control] [Division 23 BCAS] Contractor**. Controllers operators and contactors shall be located for easy access from the ceiling below the unit. Temperature control functions and sequences shall be as specified in **[Section 23 06 10, "HVAC Sequence of Operation",] [Division 23]** and as shown on the Drawings. **[The terminal unit manufacturer shall provide an appropriately sized [120] [277] volt control power transformer to serve the terminal unit controller.]** An air flow sensor calibration curve label shall be attached to each terminal unit in a location visible from the unit controller.
- N. **Unit Performance:** The following performance tests shall be performed by an independent testing lab to verify compliance prior to equipment submittal. Acceptability of the testing facilities shall be subject to review by the Engineer. Cold air shall be supplied at 55°F and bypass air at 75°F. Test results and criteria which shall be considered acceptable are as follows:
 1. Radiated sound power levels shall not exceed **[NC 35] [NC 40]** at unit with maximum unit discharge cfm, 1.0" inlet static pressure and 0.35" outlet static pressure with any percentage of primary air.

[USE NC 35 CRITERIA FOR QFPC AND NC 40 CRITERIA FOR MFV]

<u>Band</u>	<u>Hertz</u>	<u>NC [35] [40] Criteria</u>
1	63	[60] [64] dB
2	125	[53] [57] dB
3	250	[46] [51] dB
4	500	[40] [45] dB
5	1000	[36] [41] dB
6	2000	[34] [39] dB
7	4000	[33] [38] dB
8	8000	[32] [37] dB

- 2. Test to be conducted in a mock-up condition approved by the Engineer. Discharge noise level in sound pressure measured 5' from the terminal unit in a duct with 1/2" acoustical lining shall be a maximum of NC 30. The 5' duct shall include one elbow with turning vanes.
- 3. Temperature variation at the fan discharge (with fan operating) shall not vary more than 3°F across the opening with 50% cold air at 55°F and 50% at 75°F.

4. Cold deck cfm fluctuation at any given flow setting over static pressure range shall be a maximum of +10%.
 5. Dampers shall prevent leakage in excess of 2% of maximum rated terminal unit capacity when operating against **[3"] [6"]** of static pressure (SP).
 6. Maximum fan motor horsepower shall be as indicated on the Drawings and at no time shall power draw exceed motor rating. Fans shall be balanced or arranged to prevent motor overload.
- O. **[Samples: A sample production run unit of each type [and size] of terminal unit specified on the project shall be submitted for examination and approval by the Engineer, Owner and Testing and Balancing (TAB) [Consultant] [Contractor]. If approved, the unit shall remain at the job site for comparison with units as shipped to project. The unit may be installed in the project at an accessible, marked location. The unit manufacturer shall test and certify that each terminal unit provided for the project has been constructed and tested as specified and are the same as the sample units.] [Where only one unit of each type is required for testing, the submitted unit shall be the largest size unit of that type scheduled for the project.]**
- P. **[Shipment Testing: A random sampling of the terminal unit supplied for the project and selected by the Engineer or Owner's Representative will be tested for conformance to this specification. The contractor shall allow sufficient time during construction and space for the TAB [Consultant] [Contractor] to perform all testing as may be required.]**
1. **[If the results of the Shipment Testing show that any of the units do not perform as specified, then additional units shall be tested. If this testing in the Engineer's opinion shows that 10% or more of the units tested do not perform as specified, then 100% of all sizes of the units shall be tested for conformance with these specifications. The results of that testing shall be reviewed carefully between the Contractor, manufacturer, Owner, and the Engineer. A method of repair or replacing the units shall be negotiated. The Owner, however, shall maintain the right of final approval of any proposed solution. All testing shall be at no additional expense to the Owner or Engineer.]**
- Q. **[Should for any reason the testing described above under "Sample" and "Shipment Testing" prove that any of the units do not perform as specified, the unit manufacturer shall be responsible for all subsequent labor, travel, travel expenses, and incidental expenses, penalties, or other costs required to prove that the units perform as specified. This shall include, but not be limited to, the labor, travel and incidental expenses of Engineer[,] [and] Owner [and TAB Consultant].]**
- 2.3 SINGLE DUCT VAV AIR VALVE TERMINAL UNITS:
- A. **General:** Provide pressure independent single duct VAV air valve terminal units consisting of a sheet metal housing with a control damper, damper operator, **[heating coil]** and flow controls. Single duct VAV air valve/terminal units shall be compatible with the temperature controls as specified in **[Section 23 06 00, "Building Controls"] [Division 23**. Terminal unit capacities and sizes shall be as scheduled and shown on the Drawings.
 - B. **Housing:** Shall be constructed of 22 gauge minimum galvanized sheet metal with mechanical seals and gaskets to minimize housing leakage. Housing shall be insulated with one inch (1"), dual density coated fiberglass insulation meeting the requirements of NFPA 90A and UL 181 **[and protected with perforated steel liner]**. Housing shall be provided with a round or oval inlet for use with flexible duct (1800 fpm maximum velocity) and a rectangular outlet for slip and drive connection to sheet metal ductwork (1600 fpm maximum velocity).
 - C. **Control Dampers:** Shall be of a low leakage, opposed blade or single blade design with galvanized steel blades and self-lubricating bearings. Dampers shall be selected to limit pressure drop to 0.010" wc pressure loss when operating at a velocity of 2000 fpm.
 - D. **Damper Operator:** Shall be a **[pneumatic] [electric]** type normally closed damper operator rigidly mounted to the terminal unit and connected to the damper with an adjustable linkage. Operators shall be sized to properly operate the unit dampers. Damper shall be factory-mounted and **[piped] [wired]** including all controls required for operation, except **[main air and thermostat] [control wiring]** connections. Operator**[s] [springs]** shall be selected to coordinate with the control sequence shown

on the Drawings and specified. All exposed operational/linkage components shall be protected with removable metal covers.

- E. **[Electric Heating Coils:** Electric heating coils shall be provided on single duct VAV terminal units where scheduled or shown on the Drawings. 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. 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 [a pneumatic heater control switch (PE switch)] [electronic controls] for each heater contactor.]

[OR]

- F. **[Hot Water Heating Coils:** Hot water heating coils shall be provided on single duct VAV terminal units, where scheduled or shown on the Drawings. Hot water heating coils shall be constructed with 0.010" aluminum plate fin with collars drawn, belled and firmly bonded to 1/2" diameter [0.020"] [0.035"] wall copper tubes. Coil headers shall be brass or bronze. No soldering or tinning shall be used in the bonding process. Coils shall have galvanized steel casing and [manual] [automatic] air vents. Coil header and U-bends shall be insulated and shall not be exposed. Coils shall be provided with automatic air vents and drain valves. Factory test coils with 300 psig air pressure under water. Coil face velocity shall not exceed 700 fpm. Coils shall have a maximum of 12 fins per inch. Coil air and water pressure drops shall not exceed scheduled maximums.]

[INCLUDE FOR HOT WATER COILS ONLY]

- G. **[Hot Water Coil Valves:** Valves shall be pneumatically-operated and shall be furnished and installed under [Section 23 06 00, "Building Control and Automation Temperature Controls",] [shall be electrically-operated and shall be furnished, piped, and wired with the terminal unit.]

[VERIFY PROJECT REQUIREMENTS]

- H. **Leakage:** Overall leakage for the control damper and pressurized portions of the housing shall be less than 3% of nominal cfm at [3"] [6"] SP, as rated by ARI 880 (latest Edition).
- I. **Controls:** Pressure independent volume controls shall be factory-installed, including a multipoint air flow sensor for inlet volume measurement, [a Titus II Flow Logic Analyzer or equal], [a DDC terminal unit controller] and related accessories and components. Controls shall provide adjustable minimum and maximum cfm limits, adjustable throttling range and a constant throttling range option. Adjustments for control settings and gauge tees for flow measurement and balancing shall be easily accessible. [DDC controllers and damper operators shall be furnished by the [Temperature Control] [Division 17 BCAS] Contractor for factory-installation, wiring and testing by the terminal unit manufacturer. Controllers shall be located for easy access] from the ceiling below the unit. Temperature control functions and sequences shall be as specified in [Section 23 06 10 "HVAC Sequence of Operation",] [Division 23] and as shown on the Drawings. [The terminal unit manufacturer shall provide an appropriately sized [120] [277] volt control power transformer to serve the terminal unit controller.] An air flow sensor calibration curve label shall be attached to each terminal unit in a location visible from the unit controller.
- J. **Unit Performance:** The following performance tests shall be performed by an independent testing lab to verify compliance prior to equipment submittal. Acceptability of the testing facilities shall be subject to review by the Engineer. Test results and criteria which shall be considered acceptable are as follows:

[VERIFY REQUIREMENTS]

1. Radiated sound power levels shall not exceed **[NC 30] [NC 35]** for any value unit discharge cfm, **[one inch (1")]** [_____] " inlet static pressure and 0.35" outlet static pressure with any percentage of primary air.

<u>Band</u>	<u>Hertz</u>	<u>NC [30] [35] Criteria</u>
1	63	[57] [60] dB
2	125	[48] [53] dB
3	250	[41] [46] dB
4	500	[35] [40] dB
5	1000	[31] [36] dB
6	2000	[29] [34] dB
7	4000	[28] [33] dB
8	8000	[27] [32] dB

Test to be conducted in a mock-up condition approved by the Engineer.

2. Discharge noise level in sound pressure measured 5' from the terminal unit in a duct with 1/2" acoustical lining shall be a maximum of NC **[25] [30]**. The 5' duct shall include one elbow with turning vanes.
3. CFM fluctuation at any given flow setting over static pressure range shall be a maximum of +10%.
4. Dampers and unit casing shall prevent leakage in excess of 3% of maximum rated terminal unit capacity when operating against **[3"] [6"]** of static pressure (SP).

K. [Samples: A sample production run unit of each type [and size] of terminal unit specified on the project shall be submitted for examination and approval by the Engineer, Owner and Testing and Balancing (TAB) [Consultant] [Contractor]. If approved, the unit shall remain at the job site for comparison with units as shipped to project. The unit may be installed in the project at an accessible, marked location. The unit manufacturer shall test and certify that each terminal unit provided for the project has been constructed and tested as specified and are the same as the sample units.] [Where only one unit of each type is required for testing, the submitted unit shall be the largest size unit of that type scheduled for the project.]

L. [Shipment Testing: A random sampling of the terminal unit supplied for the project and selected by the Engineer or Owner's Representative will be tested for conformance to this specification. The contractor shall allow sufficient time during construction and space for the TAB [Consultant] [Contractor] to perform all testing as may be required.]

1. **[If the results of the Shipment Testing show that any of the units do not perform as specified, then additional units shall be tested. If this testing in the Engineer's opinion shows that 10% or more of the units tested do not perform as specified, then 100% of all sizes of the units shall be tested for conformance with these specifications. The results of that testing shall be reviewed carefully between the Contractor, manufacturer, Owner, and the Engineer. A method of repair or replacing the units shall be negotiated. The Owner, however, shall maintain the right of final approval of any proposed solution. All testing shall be at no additional expense to the Owner or Engineer.]**

M. [Should for any reason the testing described above under "Sample" and "Shipment Testing" prove that any of the units do not perform as specified, the unit manufacturer shall be responsible for all subsequent labor, travel, travel expenses, and incidental expenses, penalties, or other costs required to prove that the units perform as specified. This shall include, but not be limited to, the labor, travel and incidental expenses of Engineer[,] [and] Owner [and TAB Consultant].]

2.4 DOUBLE DUCT TERMINAL UNITS:

- A. General: Provide **[variable] [constant]** volume, pressure independent double duct terminal units consisting of a sheet metal housing with control dampers, damper operators, mixer-attenuator and flow

controls. Double duct terminal units shall be compatible with the temperature controls as specified in **[Section 23 06 00, "Building Controls"] [Division 23]**. Terminal unit capacities and sizes shall be as scheduled and shown on the Drawings.

- B. **Housing:** Shall be constructed of 22 gauge minimum galvanized sheet metal with mechanical seals and gaskets to minimize housing leakage. Housing shall be insulated with one inch (1"), dual density coated fiberglass insulation meeting the requirements of NFPA 90A and UL 181 **[and protected with perforated steel liner]**. Housing shall be provided with a round or oval inlet for use with flexible duct (1800 fpm maximum velocity) and a rectangular outlet for slip and drive connection to sheet metal ductwork (1600 fpm maximum velocity).
- C. **Mixer-attenuator:** Each unit shall include a mixer-attenuator section as an integral part of the unit to minimize downstream stratification. The mixer shall provide less than 1°F downstream variation with 10°F difference between the two inlets. Certified independent test lab data shall be submitted for approval subject to witness testing by the Engineer or Owner's Representative.
- D. **Control Dampers:** Shall be of a low leakage, opposed blade or single blade design with galvanized steel blades and self-lubricating bearings. Dampers shall be selected to limit pressure drop to 0.25" wc pressure loss when operating at a velocity of 2000 fpm. Dampers shall be arranged to allow units to operate at constant or variable volume air flow.
- E. **Damper Operators:** Shall be **[pneumatic] [electric]** type normally open damper operators rigidly mounted to the terminal unit and connected to the dampers with an adjustable linkage. Operators shall be sized to properly operate the unit dampers. Damper shall be factory-mounted and **[piped] [wired]** including all controls required for operation, except **[main air and thermostat] [control wiring]** connections. Operator[s] **[springs]** shall be selected to coordinate with the control sequence shown on the Drawings and specified. All exposed operational/linkage components shall be protected with removable metal covers.

[VERIFY PROJECT REQUIREMENTS]

- F. **Leakage:** Overall leakage for the control damper and pressurized portions of the housing shall be less than 3% of nominal cfm at **[3"] [6"]** SP, as rated by ARI 880 (latest Edition).
- G. **Controls:** Pressure independent volume controls shall be factory-installed, including multipoint air flow sensors for cold deck inlet volume measurement and mixer-attenuator discharge flow measurement, **[a pneumatic volume controller] [a DDC terminal unit controller]** and related accessories and components required to operate the unit as a dual duct **[variable] [constant]** volume unit. Controls shall provide adjustable minimum and maximum cfm limits, adjustable throttling range and a constant throttling range option. Adjustments for control settings and gauge tees for flow measurement and balancing shall be easily accessible. **[DDC controllers and damper operators shall be furnished by the [Temperature Control] [Division 23 BCAS] Contractor for factory-installation, wiring and testing by the terminal unit manufacturer. Controllers shall be located for easy access]** from the ceiling below the unit. Temperature control functions and sequences shall be as specified in **[Section 23 06 10, "HVAC Sequence of Operation",] [Division 23]** and as shown on the Drawings. **[The terminal unit manufacturer shall provide an appropriately sized [120] [277] volt control power transformer to serve the terminal unit controller.]** An air flow sensor calibration curve label shall be attached to each terminal unit in a location visible from the unit controller.
- H. **Unit Performance:** The following performance tests shall be performed by an independent testing lab to verify compliance prior to equipment submittal. Acceptability of the testing facilities shall be subject to review by the Engineer. Cold air shall be supplied at 55°F and warm air shall be supplied at **[80°F] [_____°F]**. Test results and criteria which shall be considered acceptable are as follows:

[VERIFY REQUIREMENTS]

- 1. Radiated sound power levels shall not exceed **[NC 30] [NC 35]** for any value unit discharge cfm, **[2.0"] [_____"]** inlet static pressure and 0.35" outlet static pressure with any percentage of cold air.

<u>Band</u>	<u>Hertz</u>	<u>NC [30] [35]</u> <u>Criteria</u>
-------------	--------------	--

1	63	[57] [60] dB
2	125	[48] [53] dB
3	250	[41] [46] dB
4	500	[35] [40] dB
5	1000	[31] [36] dB
6	2000	[29] [34] dB
7	4000	[28] [33] dB
8	8000	[27] [32] dB

Test to be conducted in a mock-up condition approved by the Engineer.

2. Discharge noise level in sound pressure measured 5' from the terminal unit in a duct with 1/2" acoustical lining shall be a maximum of NC [25] [30]. The 5' duct shall include one elbow with turning vanes.
 3. Temperature variation at the mixer-attenuator discharge shall not vary more than 3°F across the opening with 50% cold air at 55°F and 50% warm air at [80°F] [____°F].
 4. CFM fluctuation at any given flow setting over static pressure range shall be a maximum of +10%.
 5. Dampers and unit casing shall prevent leakage in excess of 3% of maximum rated terminal unit capacity when operating against [3"] [6"] of static pressure (SP).
- I. **[Samples: A sample production run unit of each type [and size] of terminal unit specified on the project shall be submitted for examination and approval by the Engineer, Owner and Testing and Balancing (TAB) [Consultant] [Contractor]. If approved, the unit shall remain at the job site for comparison with units as shipped to project. The unit may be installed in the project at an accessible, marked location. The unit manufacturer shall test and certify that each terminal unit provided for the project has been constructed and tested as specified and are the same as the sample units.] [Where only one unit of each type is required for testing, the submitted unit shall be the largest size unit of that type scheduled for the project.]**
- J. **[Shipment Testing: A random sampling of the terminal unit supplied for the project and selected by the Engineer or Owner's Representative will be tested for conformance to this specification. The contractor shall allow sufficient time during construction and space for the TAB [Consultant] [Contractor] to perform all testing as may be required.]**
1. **[If the results of the Shipment Testing show that any of the units do not perform as specified, then additional units shall be tested. If this testing in the Engineer's opinion shows that 10% or more of the units tested do not perform as specified, then 100% of all sizes of the units shall be tested for conformance with these specifications. The results of that testing shall be reviewed carefully between the Contractor, manufacturer, Owner, and the Engineer. A method of repair or replacing the units shall be negotiated. The Owner, however, shall maintain the right of final approval of any proposed solution. All testing shall be at no additional cost to the Owner or Engineer.]**
- K. **[Should for any reason the testing described above under "Sample" and "Shipment Testing" prove that any of the units do not perform as specified, the unit manufacturer shall be responsible for all subsequent labor, travel, travel expenses, and incidental expenses, penalties, or other costs required to prove that the units perform as specified. This shall include, but not be limited to, the labor, travel and incidental expenses of Engineer[,] [and] Owner [and TAB Consultant].]**

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Except as otherwise indicated, install HVAC terminal units including components and controls required for operation, in accordance with manufacturer's instructions.
- B. Location: Locate each unit accurately in the position indicated in relation to other work. Position unit with sufficient clearance for normal service and maintenance, including clearance for cabinet removal.

- C. Supports: Minimum support requirements for terminal units shall be as follows. Terminal units weighing less than 150 pounds shall be supported by four 16 gauge, one inch (1") wide sheet metal straps with ends turned under bottom of unit at corners and secured by two maximum 3/4" long by 1/4" diameter sheet metal screw per strap. The other strap end shall be attached to the structure by 1/4" diameter threaded bolt into the concrete insert or into drilled-hole threaded concrete expansion anchor. Boxes over 150 pounds in weight shall be supported the same as described above except 1/4" diameter sheet metal screws shall be located with one screw on the side of the unit and one screw on the bottom of the unit. Seal all screw penetrations into the terminal unit air stream. **[Refer to Section 15250 for terminal unit vibration isolation requirements. Spring isolated terminal units shall be supported using channel and threaded rod.]**
 - D. Leveling: Level terminal units to the tolerances recommended by the manufacturer.
 - E. Flow Graphs: Graphs shall be provided to coordinate pressure at flow measuring taps with unit primary cfm.
 - F. Unit Connections: Duct connections shall be the more stringent of the connections detailed on the Drawings and the terminal unit manufacturers recommendations.
- 3.2 TESTING:
- A. General: Installed terminal units shall be leakage tested with the connected ductwork.
 - B. **[Sample Testing: Sample terminal units shall be leakage tested by the project Testing and Balancing [Consultant] [Contractor] in the presence of the Engineer and Owner's Representative.]**
 - C. **[Shipment Testing: Leakage testing of randomly selected terminal units shall be performed by the project Testing and Balancing [Consultant] [Contractor] on site, prior to installation. Units to be tested shall be selected on site by the Engineer or Owner's Representative.]**
- 3.3 IDENTIFICATION:
- A. Refer to Section 23 03 00 for applicable painting, nameplates and labeling requirements.
- END OF SECTION 23 36 00**

SECTION 23 37 13 - AIR DISTRIBUTION DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide air distribution devices and accessories as specified, scheduled, and shown on the Drawings.
- B. Types: The types of air distribution devices required for the project include, but are not limited to:
 - 1. Ceiling diffusers.
 - 2. Registers and grilles.
 - 3. Light troffer boots.
 - 4. Linear slot diffusers.
 - 5. Perimeter supply/return slot diffusers.

1.3 QUALITY ASSURANCE:

- A. Manufacturers: Devices manufactured by Metal-Aire, Titus, Krueger, Anemostat/Waterloo, Aeronca, Carnes, or Barber-Coleman will be acceptable if the devices furnished comply with these Specifications, the conditions scheduled and are similar in appearance and performance to the units scheduled.
- B. NFPA Compliance: Comply with National Fire Protection Association (NFPA) Standard NFPA 90, as applicable to air diffuser construction and installation.
- C. Design Compliance: When directed by the Engineer, test air outlets to verify compliance with these Specifications. Perform all revisions required to comply with terminal velocity, noise level or maximum temperature variation requirements at no cost to the Owner or Engineer.
- D. Air Distribution Equipment: Maximum space temperature variation shall not exceed 2°F through the conditioned area from 2' above the floor, to 7' above the floor. The air outlets shall be selected by the manufacturer to suit the volume, throw and noise level scheduled as shown on the Drawings and maintain maximum terminal velocities of 50 fpm, unless otherwise indicated.

1.4 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
 - 1. Submit cutsheets on air devices clearly indicating all features, accessories, mounting provisions, throw, pressure drop, noise criteria, and other pertinent performance data clearly indicated.
 - 2. Submit dimensioned drawings for all custom and special dimension linear slot diffusers and air devices.
 - 3. Submit test data and results as specified herein. Test results shall be certified by an authorized officer of the company.
 - 4. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver air distribution devices in factory-fabricated water-resistant wrapping.
- B. Handle air distribution devices carefully to avoid damage to material component, enclosure, and finish.
- C. Store air distribution devices in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 AIR DISTRIBUTION DEVICE GENERAL REQUIREMENTS:

- A. General: Provide air distribution devices of the size, shape, and type, constructed of materials and components and with finishes as scheduled and shown on the Drawings. Grilles, registers and ceiling outlets shall be provided with sponge rubber or soft felt gaskets. If a manufacturer other than the one scheduled is used, the sizes shown on the Drawings shall be checked for performance, noise level, face velocity, throw, pressure drop, etc., before the submittal is made. Selections shall meet the manufacturer's own published data for the above performance criteria. The throw shall be such that the velocity at the end of the throw in the five foot occupancy zone will be not more than 50 fpm nor less than 25 fpm. Noise levels shall not exceed those published in the ASHRAE Guide for the type of space being served (NC level).
- B. Compatibility: Air distribution devices shall be fully compatible with the surfaces in which they are installed and shall be provided with all required mounting accessories for installation in the actual construction at the installation location.
- C. Finishes: All ceiling and wall mounted air devices shall be painted white or off white unless specified otherwise and all air devices shall be the same color. Where the factory finish on all devices is not the same as determined by the Architect/Engineer, then the Division 15 Contractor shall be responsible for coordinating field painting of air devices by the Division 9 Contractor. The Division 15 Contractor shall be responsible for all costs associated with painting of white or off white air devices. Special color painting of air devices shall be the responsibility of the Division 9 Contractor. The Architect/Engineer's decision on white color compatibility is final.
- D. Ceiling Diffusers: Provide diffusers with corrosion resistant treated surfaces and finished in off-white baked enamel unless otherwise specified, scheduled, or shown on the Drawings. Provide opposed volume control dampers with supply air diffusers where scheduled. Where applicable, provide adapters with diffusers to permit connection to round supply duct. Perforated diffuser may be used in retrofit installations only; beveled (step-down) style diffuser shall be used in new construction. The interior of all perforated plate diffusers shall be painted flat black. Perforated plate supply air diffusers shall have pattern control blades installed in the diffuser neck. Pattern controllers attached to the perforated plate are **not** acceptable. Provide concealed fastening on all ceiling diffusers.
- E. Registers and Grilles: Provide registers which contain a key-operated multilouvered opposed blade damper operable from the face side, unless scheduled otherwise. Supply air registers shall be of the double deflection type, unless scheduled. Return air grilles and registers shall have fixed face blades and match the face of the supply air registers, unless scheduled otherwise. Provide concealed fastening for all registers and grilles.
- F. Double-sided Light Troffer Boots (not allowed in new construction):
1. Troffer slot type diffusers shall consist of nominal 48" long supply plenums on each side of the lighting fixture, a cross-over duct connecting the two plenums, and a single oval duct side entry connection. The air volume shall be as scheduled or shown on the Drawings.
 2. The troffer boot manufacturer shall coordinate the attachment, shape, height, and similar features of the supply plenum with the manufacturer of the air handling troffer type lighting fixture specified in Division 23. The maximum combined height of the light and boot shall be 8" above finished ceiling. Each air troffer shall include an air pattern control device, if required, to coordinate with the lighting fixtures furnished. The lighting fixture and troffer boot assembly shall be designed to direct the supply air horizontally at the ceiling.
 3. The lighting fixture and troffer boot assembly shall be tested as a unit at the diffuser manufacturer's laboratory. Certified copies of the test results shall be delivered to the Engineer for review. The test data shall include AK factors for an Anor velometer, diffuser static pressure drop, horizontal airflow, spread, sound data, and velocity profile for horizontal airflow at rates in 20 cfm increments from 60 to 200 cfm. Test data shall be based on a 55°F supply air temperature and 20°F temperature differential. Maximum leakage of the assembly shall not exceed 10% of design flow rate. Upon review of certified test results, the Engineer may require additional tests which will be witnessed by the Engineer, at no additional cost to the Owner or Engineer.
 4. The plenum shall be painted flat black on exposed and inner surfaces as viewed from below the ceiling system. Plenum shall be constructed of at least 26 gauge galvanized steel and shall be

substantially airtight, supported, and reinforced as required. **[The entire troffer shall be externally insulated with ductwrap insulation with a continuous vapor barrier.]**

5. The performance shall equal or exceed the following when mounted on the 2 x 4 light fixture specified in Division 16.

<u>CFM</u>	<u>PRESSURE DROP INCHES W.C.</u>	<u>THROW @ 50 FPM TERMINAL VELOCITY</u>	<u>N.C.*</u>
60	0.04	4'	Less than 20
100	0.07	6'	Less than 20
120	0.10	7'	Less than 20
160	0.17	8'	Less than 25
200	0.28	10'	Less than 35

* Based on 10 dB room absorption.

G. Single Side Light Troffer (not allowed in new construction)::

1. The single side troffer shall be similar to the double-sided light troffer boot, but shall have one supply plenum on the side of a light fixture, with a single 6" oval duct side entry connection. The maximum combined height shall not exceed 7" above finished ceiling.
2. Test data shall be similar to that specified for the boot, except between 40 and 120 cfm. Performance shall equal or exceed the following when mounted on the 2 x 4 light fixture specified in Division 16.

<u>CFM</u>	<u>PRESSURE DROP INCHES W.C.</u>	<u>THROW @ 50 FPM TERMINAL VELOCITY</u>	<u>N.C.*</u>
40	0.04	3'	Less than 20
60	0.08	6'	Less than 20
80	0.14	8'	Less than 20
120	0.34	17'	Less than 40

* Based on 10 dB room absorption.

H. High Induction Perimeter Supply/Return Slot Diffuser:

1. Provide slot-type supply/return (where scheduled) diffuser with length and width scheduled or shown on the Drawings. The supply/return diffuser shall be installed above the ceiling and located as indicated on the Architectural and Mechanical Drawings. **[The perimeter supply linear boot diffusers shall have an internal, fixed, curved, aerodynamically shaped outlet designed to provide the maximum amount of induced secondary room air.]** The return air slot (where scheduled) shall be located so that the supply air pattern will not be affected. The supply air shall be discharged horizontally along the ceiling with a down discharge center section (where scheduled).
2. The diffuser shall be designed, tested, and constructed in a manner so as to comply with the performance criteria and sound level requirements specified hereinafter. Diffuser shall be constructed of at least 24 gauge galvanized steel and shall be reinforced as required. The air volume, length and duct connection size shall be as scheduled or shown on the Drawings. The diffuser manufacturer shall coordinate the attachment, support, tee spacing, and similar features of the diffuser with the ceiling Subcontractor.
3. The entire assembly shall be tested as a unit at the manufacturer's laboratory. Submit certified copies of the test results to the Engineer for review. The test data shall include AK factors for an Anor velometer, sound data, diffuser static pressure drop, horizontal air throw, and drop for the air supply rates per lineal foot of diffusers indicated below. The test data shall be based on a 55°F air supply temperature, a 20°F temperature differential and an 85°F heating supply air temperature.

4. The diffuser shall be painted flat black on interior surfaces and the exposed surfaces as viewed from below the ceiling system shall be painted flat black **[the entire diffuser assembly shall be externally insulated with ductwrap insulation with a continuous vapor barrier]**.
5. The perimeter ceiling supply/return linear boot diffuser shall be similar to the Titus Model scheduled and detailed on the Drawings and shall be designed to equal or exceed the following performance characteristics:

<u>CFM/ LIN. FT. DIFFUSER</u>	<u>MAX. DIFFUSER STATIC PRESSURE LOSS - IN W.C.</u>	<u>THROW @ 50 FPM TERMINAL VELOCITY</u>	<u>NC LEVEL*</u>
<u>Titus Nova Model - N1/N1D (R with Return Slot)</u>			
30	0.1	7'	Less than 20
40	0.1	14'	Less than 23
50	0.1	17'	Less than 30
60	0.15	19'	Less than 34
70	0.20	21'	Less than 38
<u>Titus Nova Model - N4/N4D (R with Return Slot)</u>			
30	0.010	16'	Less than 20
40	0.15	19'	Less than 26
50	0.20	22'	Less than 33

* Based on 10 dB room absorption.

6. The Engineer will have the option to witness additional tests after receipt of certified test results to verify compliance with these Specifications.

2.2 AIR DISTRIBUTION DEVICES:

- A. Perforated Plate Type [] Supply Air Devices (retrofit only): Devices shall be aluminum/steel construction with an aluminum face and aluminum or steel pans. Frames shall have mitered corners and be suitable for lay-in installation. Perforated faces shall have a concealed hinge mechanism such that the plate remains attached to the frame when opened. Exposed external parts shall have a factory applied white or off-white baked enamel finish. Visible internal parts shall be factory painted flat black. All steel components shall be fully phosphatized prior to painting and there shall be no unpainted steel parts. Diffusers shall incorporate internal pattern control louvers. The use of pattern control devices attached to the perforated plate is not acceptable. Air devices shall be 4-way diffusion pattern unless noted otherwise on the drawings. An opposed blade balancing damper shall be provided where scheduled. Device neck size shall be as shown on the drawings. Air device frame shall be suitable for use with the ceiling in which the device is installed. Metal-Aire Series 7000 PCS-AB-6, J and J Model 1200 or Krueger Model 1100.
- B. Perforated Plate Type [] Supply Air Devices (retrofit only): Devices shall be aluminum/steel construction with an aluminum face and aluminum or steel pans. Frames shall have mitered corners and be suitable for concealed fastener surface installation. Perforated faces shall have a concealed hinge mechanism such that the plate remains attached to the frame when opened. Exposed external parts shall have a factory applied white or off-white baked enamel finish. Visible internal parts shall be factory painted flat black. All steel components shall be fully phosphatized prior to painting and there shall be no unpainted steel parts. Diffusers shall incorporate internal pattern control louvers. The use of pattern control devices attached to the perforated plate is not acceptable. Air devices shall be 4-way diffusion pattern unless noted otherwise on the drawings. An opposed blade balancing damper shall be provided where scheduled. Device neck size shall be as shown on the drawings. Air device frame shall be suitable for use with the ceiling in which the device is installed. Metal-Aire Series 7000 PCS-AB-1, J and J Model 1200 Series or Krueger Model 1100 Series.
- C. Perforated Plate Type [] Supply Air Devices (retrofit only): Devices shall be aluminum/steel construction with an aluminum face and aluminum or steel pans. Frames shall have mitered corners. Perforated faces shall have a concealed hinge mechanism such that the plate remains attached to the

frame when opened. Exposed external parts shall have a factory applied white or off-white baked enamel finish. Visible internal parts shall be factory painted flat black. All steel components shall be fully phosphatized prior to painting and there shall be no unpainted steel parts. Diffusers shall use deflectors attached to the perforated plate in a secure manner to control pattern. Air devices shall be 4-way diffusion pattern unless noted otherwise on the drawings. An opposed blade balancing damper shall be provided where scheduled. Device neck size shall be as shown on the drawings. Air device frame shall be suitable for use with the ceiling in which the device is installed. Titus Type PAS, Metal-Aire Series 7500 or J and J Model 1235.

- D. Perforated Plate Type [] Exhaust and Return Air Devices (retrofit only): Devices shall be aluminum/steel construction with an aluminum face and aluminum or steel pans. Frames shall have mitered corners. Perforated faces shall have a concealed hinge mechanism such that the plate remains attached to the frame when opened. Exposed external parts shall have a factory applied white or off-white baked enamel finish. Visible internal parts shall be factory painted flat black. All steel components shall be fully phosphatized prior to painting and there shall be no unpainted steel parts. An opposed blade balancing damper shall be provided where scheduled. Device neck size shall be as shown on the drawings. Air device frame shall be suitable for use with the ceiling in which the device is installed. Titus Type PAR, Metal-Aire Series 7000 PCR-AB-6, J and J Model AL-1290 Series or Krueger Model 1190 Series.
- E. Perforated Plate Type [] Exhaust and Return Air Devices (retrofit only): Devices shall be aluminum/steel construction with an aluminum face and aluminum or steel pans. Frames shall have mitered corners and be suitable for concealed fastener surface installation. Perforated faces shall have a concealed hinge mechanism such that the plate remains attached to the frame when opened. Exposed external parts shall have a factory applied white or off-white baked enamel finish. Visible internal parts shall be factory painted flat black. All steel components shall be fully phosphatized prior to painting and there shall be no unpainted steel parts. An opposed blade balancing damper shall be provided where scheduled. Device neck size shall be as shown on the drawings. Air device frame shall be suitable for use with the ceiling in which the device is installed. Metal-Aire Series 7000 PCR-AB-1, J and J Model AL-1290 Series or Krueger Model 1190 Series.
- F. Louver Face Type [] Square Ceiling Supply Diffusers: Diffusers shall be all aluminum construction with mitered corner V-bevel border style surface frames suitable for use with the ceiling in which it is installed. The entire grille shall have a factory applied white or off-white baked enamel finish. Air devices shall be 4-way diffusion pattern unless noted otherwise on the drawings. An opposed blade balancing damper shall be provided where scheduled. Device neck size shall be as shown on the drawings. Metal-Aire Series 5000 M-2, J and J Model 1100 (aluminum), Krueger Series SH or Titus Model TDC-AA Series.
- G. Louver Face Type [] Square Ceiling Supply Diffusers: Diffusers shall be all aluminum construction with mitered corner frames suitable for lay-in mounting. The entire grille shall have a factory applied white or off-white baked enamel finish. Air devices shall be 4-way diffusion pattern unless noted otherwise on the drawings. An opposed blade balancing damper shall be provided where scheduled. Device neck size shall be as shown on the drawings. Metal-Aire Series 5000 M-6, J and J Model 1100 Series (aluminum), Krueger Series SH or Titus Model TDC-AA Series.
- H. Linear Slot Type [] Air Devices: Devices shall be continuous, extruded aluminum slot diffusers with mitered corners. Diffusers shall have 3/4" slots as scheduled and shall have extruded aluminum pattern control blades (supply slots only). Diffuser mounting frames shall be suitable for use with the ceiling in which the diffuser is installed. The entire diffuser (except pattern control blades) shall have a factory applied **[clear anodized aluminum] [white or off-white baked enamel]** finish. The pattern control blades shall have a factory applied flat black baked enamel finish. Slot diffusers shall have concealed mounting hardware. Provide insulated supply air plenums as shown on the Drawings. Titus Type ML-38 (supply slot)/MLR-38 (return slot), Metal-Aire Model 6075 (supply and return slots) or J and J Model 2070 (supply and return slots).
- I. Linear Slot Type [] Air Devices: Devices shall be continuous, extruded aluminum slot diffusers with mitered corners. Diffusers shall have 1/2" slots with 0 degrees or 15 degrees deflection as scheduled and shall be suitable for use the ceiling, wall or floor type in which the diffuser is installed. The entire diffuser shall have a factory applied **[clear anodized aluminum] [white or off-white baked**

- enamel**] finish. The pattern control blades shall have a factory-applied flat black baked enamel finish. Slot diffusers shall have concealed mounting hardware and mitered corners. Provide insulated supply **[and return]** air plenums as shown on the Drawings. Titus **[CMT-15] [CT-25]** (0 degrees deflection)/ **[CMT-16] [CT-26]** 15 degrees deflection), Metal Air Series 2100 or J and J Model 2500.
- J. Linear Slot Type [] **Air Devices:** Devices shall be high induction, side inlet slot diffusers with length and neck size as scheduled or shown on the Drawings. The diffusers shall have an aerodynamically designed, venturi-shaped air outlet designed to direct supply air horizontally across the ceiling and to provide maximum aspiration and entrainment of room air. The supply air shall maintain a ceiling pattern with varying volumes of air to minimum flow. The diffuser shall have a maximum height of 9" and shall be completely supported by two ceiling tee's on nominal 2-3/4" centers. The diffuser shall be constructed of minimum 24 gauge nonrusting steel and all surfaces exposed to view below the ceiling shall be painted flat black. **[Diffusers shall be factory-insulated with external ductwrap insulation with a continuous vapor barrier.]** Titus Nova **[N-1-8] [N-1-9] [N-4-8]** Series.
- K. Linear Slot Type [] **Air Devices:** Devices shall be high induction, side inlet, supply/return air slot diffusers with length and neck size as shown on the drawings. The diffusers shall have an aerodynamically designed, venturi shaped air outlet designed to direct supply air horizontally across the ceiling and to provide maximum aspiration and entrainment of room air and 2" outside return air slot to draw return air over the back and top of the diffuser to improve induction and minimize outside wall effect. The supply air shall maintain a ceiling pattern with varying volumes of air to minimum flow. The diffuser shall have a maximum height of 9" and shall be completely supported on two ceiling tee's on nominal 5-1/4" centers. The diffuser shall be constructed of minimum 24 gauge nonrusting steel and all surfaces exposed to view below the ceiling shall be painted flat black. **[Diffusers shall be factory-insulated with external ductwrap insulation with a continuous vapor barrier.]** Titus Nova **[N-1-8R] [N-1-9R] [N-4-8R]** Series.
- L. Linear Slot Type [] **Air Devices:** Devices shall be high induction, side inlet slot diffusers with length and neck size as shown on the drawings. The diffusers shall have an aerodynamically designed, venturi shaped air outlet designed to direct supply air from the ends of the diffuser horizontally across the ceiling and to provide maximum aspiration and entrainment of room air. The supply air shall maintain a ceiling pattern with varying volumes of air to minimum flow. Supply air from the center section shall be in a downward vertical throw pattern. The diffuser shall have a maximum height of 9" and shall be completely supported by two ceiling tee's on nominal 2-3/4" centers. The diffuser shall be constructed of minimum 24 gauge nonrusting steel and all surfaces exposed to view below the ceiling shall be painted flat black. **[Diffusers shall be factory-insulated with external ductwrap insulation with a continuous vapor barrier.]** Titus Nova **[N-1-D] [N-4-D]** Series.
- M. Linear Slot Type [] **Air Devices:** Devices shall be high induction, side inlet slot diffusers with length and neck size as shown on the drawings. The diffusers shall have an aerodynamically designed, venturi shaped air outlet designed to direct supply air from the ends of the diffuser horizontally across the ceiling and to provide maximum aspiration and entrainment of room air and a 2" outside return air slot to draw return air over the back and top of the diffuser to improve induction and minimize outside wall effect. The supply air shall maintain a ceiling pattern with varying volumes of air to minimum flow. Supply air from the center section shall be in a downward vertical throw pattern. The diffuser shall have a maximum height of 9" and shall be completely supported by two ceiling tee's on nominal 5-1/4" centers. The diffuser shall be constructed of minimum 24 gauge nonrusting steel and all surfaces exposed to view below the ceiling shall be painted flat black. **[Diffusers shall be factory-insulated with external ductwrap insulation with a continuous vapor barrier.]** Titus Nova **[N-1-DR] [N-4-DR]** Series. Linear slot Type [] air devices shall be Tee bar mounted adjustable pattern, side inlet slot diffusers with length and neck size as shown on the drawings. Slots shall be constructed of galvanized steel with exposed surfaces painted flat black. **[Diffusers shall be factory-insulated with internal duct liner insulation.]** Slot diffusers shall be designed to deliver scheduled cfm directed horizontally across the ceiling with a maximum pressure drop of 0.25" while not exceeding NC30 based upon a room absorption of 10 dB, RE 10⁻¹² watts. Slot performance shall be certified by independent lab testing. Titus Style TBD, Metal-Aire Series PD, Krueger Model TBS or J and J Series PSD.

- N. Type [] Troffer Supply Boots: Boots shall be low leakage dual outlet type with suitable for use with the light troffers installed on the project. Troffer boot inlet neck size shall be as shown on the drawings. Each troffer boot shall consist of a supply plenum on each side of the light fixture with a crossover plenum and duct connection. The plenums shall be **externally** insulated at the factory and shall be factory painted flat black on exposed and inner surfaces visible from below the ceiling. Plenums shall be minimum 24 gauge galvanized steel and shall be airtight, with alignment tabs and a stiffening flange on each side. The troffer boot manufacturer shall coordinate attachment and design of the troffer boot with the furnished light fixtures such that the troffer and boot combination will direct the supply air horizontally across the ceiling with minimum leakage. **[A sample troffer supply boot shall be tested in an independent lab in Houston, Texas to verify proper supply air performance and distribution with the light troffers actually furnished on the project.]** Titus LTTI/LPTI Type or approved equal.
- O. Type [] Troffer Supply Boots: Boots shall be low leakage single outlet type with suitable for use with the light troffers installed on the project. Troffer boot inlet neck size shall be as shown on the drawings. Each troffer boot shall consist of a supply plenum on one side of the light fixture with a duct connection. The plenums shall be **[internally] [externally]** insulated at the factory and shall be factory-painted flat black on exposed and inner surfaces visible from below the ceiling. Plenum shall be minimum 24 gauge galvanized steel and shall be airtight, with alignment tabs and a stiffening flange. The troffer boot manufacturer shall coordinate attachment and design of the troffer boot with the furnished light fixtures such that the troffer and boot combination will direct the supply air horizontally across the ceiling with minimum leakage. **[A sample troffer supply boot shall be tested in an independent lab in Houston, Texas to verify proper supply air performance and distribution with the light troffers actually furnished on the project.]** Titus LTTI/LPTI Type or approved equal.
- P. Louver Face Type [] Wall Supply Grilles: Grilles shall be all aluminum construction with 3/4" airfoil double deflection blades, mitered frames and an opposed blade balancing damper where scheduled or shown on the Drawings. Grilles shall be suitable for mounting in the wall type in which it is installed. The entire grille shall have a factory applied white or off-white baked enamel finish. Grilles shall have concealed mounting hardware and shall be provided with flush mounting frames where scheduled or required for the installation detailed on the Architectural Drawings. Titus 272-FS5-B-C-25, Metal-Aire Series 4000 VHD, J and J Model 990V-OBD-Aluminum or Krueger Series 5880-V-OBD.
- Q. Louver Face Type [] Wall Return Grilles: Grilles shall be all aluminum construction with 3/4" airfoil double deflection blades, mitered frames and an opposed blade balancing damper where scheduled or shown on the Drawings. Grilles shall be suitable for mounting in the wall type in which it is installed. The entire grille shall have a factory-applied white or off-white baked enamel finish. Grilles shall have concealed mounting hardware and be provided with flush mounting frames where required. Titus 3-FL, Metal-Aire Series 4000 Series, J and J 900 Aluminum Series or Krueger Series 5800.
- R. Lay-in Slot Diffuser Type [] Return Air Devices: Devices shall be aluminum/steel construction painted to match ceiling tee's and with perimeter slots as scheduled and provisions for installation of a ceiling tile in the center of the device. Donn Air Diffuser with plenum.
- S. Type [] Slot Return Air Boots: Boots shall be minimum 24 gauge galvanized sheet metal, constructed as detailed on the Drawings. The entire boot shall be painted flat black and shall have an appearance similar to the project supply air slot diffusers when installed.
- T. Type [] Slot Blankoff: Blankoff shall be minimum 24 gauge galvanized sheet metal, constructed as detailed on the Drawings. The entire blankoff shall be painted flat black and shall have an appearance similar to the project supply air slot diffusers when installed.
- U. Type [] Light Cove Supply Air Boot: Insulated 4' supply air boot for use with the Light Cove System supply/exhaust slot system provided for the project. Anemostat or approved equal.
- V. Type [] Light Cove Exhaust Boot: 4'exhaust boot for use with the Light Cove System supply/exhaust slot system provided for the project. Anemostat or approved equal.
- W. Type [] Garage Supply/Exhaust Grilles: Grille shall consist of a framed mesh grille in the CMU wall opening as detailed on the Architectural Drawings and furnished under another Division. This

Division to provide a framed sliding blade guillotine type damper with screw stops on the plenum side of each CMU opening.

- X. Louver Face Type [] Wall and Ceiling Return/Exhaust Grilles: Grilles shall be all aluminum construction with 45° louvers on 1/2" centers, mitered frames and an opposed blade balancing damper where scheduled. Grilles shall be suitable for mounting in the wall or ceiling type in which it is installed. The entire grille shall have a factory applied white or off-white baked enamel finish. Grilles shall have concealed mounting hardware. Titus Core 4-FL5-B-C-25, Metal-Aire Model RHD, J and J Model 590-H-OBDD or Krueger Model S585-H-OBDD.
- Y. Louver Face Type [] Wall and Ceiling Return/Exhaust Grilles: Grilles shall be all steel construction with 30 degree curved blades on 1/2" centers, mitered frames and an opposed blade balancing damper where scheduled. Grilles shall be suitable for mounting in the wall or ceiling type in which it is installed. The entire grille shall have a factory applied white or off-white baked enamel finish. Grilles shall have concealed mounting hardware. Titus Core 25-RL5-B-C025 or an approved equal.
- Z. Grid Face Type [] Wall and Ceiling Supply, Return and Exhaust Grilles: Grilles shall all aluminum construction with a 1/2" x 1/2" x 1" grid face, mitered frame and an opposed blade balancing damper where specified. Grilles shall be suitable for mounting in the wall or ceiling type in which it is installed. The entire grille shall have a factory applied white or off-white baked enamel finish. Grilles shall have exposed screw mounting hardware. Titus Core 51F05-O-A-25, Metal-Aire Model CC-5-D, J and J Model ALEC-5-OBDD or Krueger Model EGC-5-OBDD.
- AA. Perforated Plate Type [] Supply Air Devices: Devices shall be all steel construction and shall be UL listed for use in the floor/ceiling and roof/ceiling assemblies specified for the project. Frames shall have mitered corners. Perforated faces shall have a concealed hinge mechanism such that the plate remains attached to the frame when opened. Exposed external parts shall have a factory applied white or off-white baked enamel finish. Visible internal parts shall be factory painted flat black. All steel components shall be fully phosphatized prior to painting and there shall be no unpainted steel parts. Diffusers shall use deflectors attached to the perforated plate in a secure manner to control pattern. Air devices shall be 4-way diffusion pattern unless noted otherwise on the drawings. Air devices shall be provided with all required dampers, thermal links and ceramic fiber blankets. Ceramic fiber blankets shall be enclosed in an approved mesh material to allow easy handling of the blankets. Device neck size shall be as shown on the drawings. Air device frame shall be suitable for use in the ceiling in which the device is installed and shall be supported in accordance with UL requirements. Refer to Radiation Damper requirements hereinbelow for additional requirements. Titus Type PAS with Ruskin CFD5 Diffuser Radiation Damper, or J and J Model 1235 with Ruskin CFD5 Diffuser Radiation Damper.
- BB. Perforated Plate Type [] Exhaust and Return Air Devices: Devices shall be all steel construction and shall be UL-listed for use in the floor/ceiling and roof/ceiling assemblies specified for the project. Frames shall have mitered corners. Perforated faces shall have a concealed hinge mechanism such that the plate remains attached to the frame when opened. Exposed external parts shall have a factory applied white or off-white baked enamel finish. Visible internal parts shall be factory painted flat black. All steel components shall be fully phosphatized prior to painting and there shall be no unpainted steel parts. Air devices shall be provided with all required dampers, thermal links and ceramic fiber blankets. Ceramic fiber blankets shall be enclosed in an approved mesh material to allow each handling of the blankets. Device neck size shall be as shown on the drawings. Air device frame shall be suitable for use with the ceiling and which the device is installed and shall be supported in accordance with UL requirements. Refer to Radiation Damper requirements hereinbelow for additional requirements. Titus Type PAR with Ruskin CFD5 Diffuser Radiation Damper or J and J Model AL-1290 with Ruskin CFD5 Diffuser Radiation Damper.
- CC. Linear Slot Type [] Air Devices: Devices shall be Tee bar mounted adjustable pattern, side inlet slot diffusers and shall be UL-listed for use in the floor/ceiling and roof/ceiling assemblies specified for the project. Slot length and neck size shall be as shown on the drawings. Slot diffusers shall be constructed of galvanized steel and shall be provide with required thermal links and ceramic fiber blankets. All exposed diffusers surfaces shall be painted flat black. **[Diffusers shall be factory-insulated with internal duct liner insulation.]** Ceramic fiber blankets shall be enclosed in a

approved mesh material to allow easy handling of the blankets. Slot diffusers shall be designed to deliver scheduled cfm directed horizontally across the ceiling with a maximum pressure drop of 0.25" while not exceeding NC30 based upon a room absorption of 10 dB, RE 10⁻¹² watts. Slot performance shall be certified by independent lab testing. Slot diffusers shall be installed and supported in accordance with UL requirements. Continental [UAN] [UDN] or Nailor-Hart [5591] [5592].

- DD. Type [] Security Grilles: Grilles shall be all aluminum construction with mitered frames, concealed fastenings and rectangular bar louvers. Grilles shall be factory modified for proper mounting in the ceiling or wall type in which they are installed. Grille shall have a clear anodized finish. Grilles shall be directly supported from the building structure where the mounting surface does not provide an adequate structure to properly install the grille. Titus SG-15500, Metal-Aire Model 2000 SG-1 or J and J Model S590-3H-SG.
- EE. Type [] Operating Room Ceiling Supply Laminar Flow Diffusers: Diffusers shall be all aluminum construction using aluminum extrusions for framing. Framing shall be of a design such that through the application of solid plates, two separate plenums shall be formed. Air shall be admitted to the initial plenum through a side mounted oval collar. The inlet collar shall have a control mechanism, accessible behind the faceplate, to meter the air volume admitted to the upper plenum chamber. Air shall then pass through air diffusion devices in a secondary plate into the lower plenum where it is forced by pressure displacement through the diffuser perforated faceplate. The housing shall have an extruded aluminum frame with all corners continuous heli-arc welded to form an air tight shell. The perforated final diffusion faceplate shall be 14 gauge aluminum, perforated with 16% free area in a square pattern. The faceplate shall be held in place in the housing frame with an aluminum mounting with mitered and backwelded corners. The faceplate shall be attached with flush quarter-turn fasteners to allow access for balancing and filter changeout. Vinyl coated stainless steel cable safety retainers shall be provided to prevent dropping of the faceplate assembly during disassembly. The housing frame shall be suitable for use with a plaster/drywall or lay-in ceiling as shown on the Drawings. The actual mounting type shall be coordinated with the ceiling type as shown on the Architectural Drawings. The entire diffuser housing shall be finished with a white baked glass epoxy enamel. During operation of the diffuser assembly there shall be zero aspiration at the face of the perforated plate and velocities in the plane of the perforated plate shall vary no more than 10% when tested with a velometer directly to the face of the plate, to establish a uniformity of air discharge. Operating room ceiling supply laminar flow diffuser shall be Precision Air Products Series PATQ or an approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install air distribution devices 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 distribution devices properly with other work.
- C. Locations: Locations of air distribution devices shown on Drawings are approximate and shall be coordinated with other trades to make symmetrical patterns and shall be governed by the established pattern of the lighting fixtures. Where air distribution devices are installed in acoustical tile and other ceilings they shall be either centered on tile or ceiling joints as directed by Architect at job site. Coordinate location of all ceiling air devices with Architectural reflected ceiling plans. **[All devices installed in UL floor/ceiling or roof/ceiling assemblies shall be compatible with the assembly specified on the Architectural Drawings.]**
- D. Mounting Provisions: Coordinate mounting provisions and accessories required for proper installation of air devices in finish and construction at the point of installation. Refer to details on the Mechanical and Architectural Drawings for special installation details and provide all mounting accessories shown or required for the complete and proper installation of each air device.
- E. Accessories: Where scheduled, the grilles, registers and ceiling outlets shall be provided with deflecting devices and manual balancing damper. These devices shall be the standard product of the manufacturer, subject to review by the Architect, and equal to brand scheduled.

- F. Insulation: Refer to Section 23 07 00, "System Insulation", for field insulation of air devices, where required.
- G. Security Air Devices: Tamper resistant air devices in Secure Areas shall be installed in accordance with Manufacturer's recommendations for the construction types used on the project. In all cases, tamper resistant air devices shall be securely mounted to the building construction.

3.2 BALANCING ACCESSORIES:

- A. General: Employ factory-calibrated balancing cones for use in air balancing all types of ceiling outlets, linear diffusers or any other special outlet. All cones shall be calibrated for use with Alnor velometer and identified with airflow factors permanently indicated on the sides of the cones.

3.3 FIELD QUALITY CONTROL:

- A. Test: Test installed devices to demonstrate satisfactory compliance with specified and indicated requirements.
- B. Adjustment: Adjust air distribution devices to provide air distribution patterns shown on the drawings or required.
- C. Air Balancing: Balance the airflow through each air device to the volumes shown on the Drawings. Refer to Section 23 05 93 for additional balancing requirements.

END OF SECTION 23 37 13

SECTION 23 40 00 - FILTERS AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide filters and accessories as specified, scheduled, and shown on the Drawings.
- B. Types: The types of filters required for the project include, but are not limited to:
 - 1. Unit mounted pleated filters.
 - 2. **[Unit mounted roll filters.] Used for renovation projects only.**

1.3 QUALITY ASSURANCE:

- A. Manufacturers: Provide filters and accessories complying with these specifications and produced by the following:
 - 1. American Air Filter.
 - 2. Cam-Farr.

1.4 SUBMITTALS:

- A. Shop drawing submittals shall include, but are not limited to, the following:
 - 1. Cut sheets on all filter types required for the project, clearly indicating type, construction, materials, sizes, ratings, classification, and other pertinent filter information.
 - 2. A listing of all filter types and sizes to be provided for the project.
 - 3. Cut sheet on all filter housings and assemblies clearly indicating sizes, construction, connection types, ratings, features controls, and other pertinent information.
 - 4. Certification that filters and filter housings and assemblies have been coordinated with served equipment and with filter racks/banks furnished by air handling equipment manufacturers.
 - 5. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver filters and accessories in factory-fabricated water resistant packaging.
- B. Handle filters and accessories carefully to avoid damage to material components and enclosures.
- C. Store filters in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 PLEATED FILTERS:

- A. General: Provide high efficiency, pleated, disposable type filters where scheduled or shown on the Drawings.
- B. UL-listing: Filters shall be listed by Underwriters' Laboratories, Inc. as Class **[1] [2]**.
- C. Filter Media: Filter media shall be of the nonwoven cotton fabric type. The filter media shall have an average efficiency of at least 40% in accordance with ASHRAE Test Standard 52-76.
- D. Capacity: Ratings and capacity for pleated filters shall be as follows:
 - a. Four Inch: The effective filter media shall be not less than 7.0 square feet of media per 1.0 square foot of filter face area and shall contain not less than 11 pleats per linear foot. Initial resistance of 600 fpm approach velocity shall not exceed 0.35" w.g.
 - b. Two Inch: The effective filter media shall be not less than 4.6 square feet of media per 1.0 square foot of filter face area and shall contain not less than 15 pleats per linear foot. Initial resistance of 500 fpm approach velocity shall not exceed 0.28" w.g.

- c. One Inch: The effective filter media shall be not less than 2.3 square feet of media per 1.0 square foot of filter face area and shall contain not less than 16 pleats per linear foot. Initial resistance at 500 fpm approach velocity shall not exceed 0.45" w.g.
- E. Media Support Grid: The filter media support shall be a welded wire grid with an effective open area of not less than 96%. The welded wire grid shall be bonded to the filter media to eliminate the possibility of media oscillation and media pull away. The media support grid shall be formed in such a manner that it effects a radial pleat design, allowing total use of filter media.
- F. Enclosing Frame: The filter enclosing frame shall be constructed of a rigid, heavy-duty, high wet-strength beverage board, with diagonal support members bonded to the air entering and air exit side of each pleats, to ensure pleat stability. The inside periphery of the enclosing frame shall be bonded to the filter pack, eliminating the possibility of air bypass.
- G. Manufacturers: Filters shall be MERV 8 High Efficiency rated, American Air Filter PerfectPleat, Farr 30-30 or an approved equal.

2.2 PLEATED FILTER RACKS:

- A. General: Pleated filters shall be installed in V-bank or flat filter racks as required to provide maximum filter velocity as scheduled or shown on the Drawings. Racks shall be provided **[with air handling units and are] [under this Section for installation on air handling units which are]** specified in Section 23 74 10, "Packaged Air Handling Units", and Section 23 74 20, "Custom Air Handling Units".
- B. Filter Racks: **Provide American Air Filter, Farr or equal galvanized steel [V-bank] [flat] filter racks suitable for mounting on the air handling equipment which it serves. Racks shall be equipped with gaskets and spring type positive sealing fasteners to hold filters in place. Fasteners shall be removable without the use of tools.]**

2.3 ROLL FILTERS: [To be used for renovation projects only.]

- A. General: **Provide side access automatically renewable roll filter assemblies for air handling units and other applications where scheduled or shown on the Drawings. Filter sizes and capacities shall be as scheduled and required for the intended application.**
- B. Operation: **Rolls of media shall be installed at one side of the filter and intermittently moved into the airstream so as to maintain a substantially constant dirt load. The media shall be compactly rerolled automatically on disposable spools at the other side of the filter after it has accumulated its dirt load. The filter shall be equipped with a full height spring load pressure bar to ensure compact rewinding of the media. Each rewind spool section shall incorporate a mechanical antisag device to prevent air leakage past the upper horizontal edge of the media blanket. Both clean and dirty media rolls shall be completely enclosed and out of contact with the moving airstream.**
- C. Construction: **Filter assembly shall be constructed of galvanized sheet metal with suitable provisions for connection to the served air handling unit and associated ductwork. A metal media feed tape, reel and hook shall be supplied to install new media across the filter face, making it unnecessary to enter the duct to replace media.**
- D. Filter Media: **Media shall be of spun glass fibers bonded with a cured thermosetting resin, and shall have a nominal thickness of 2". It shall have a graduated density in the direction of the airflow, with the larger interstices on the air entering side, with a corresponding decrease in glass fiber size.**
 - 1. **Media shall have a compressibility which will allow approximately 65'of material to be wound on a 13" diameter, expandable, steel core spool with integral steel guide flanges at both ends.**
 - 2. **Media shall be charged with an odorless and flameproof adhesive which shall not flow while in storage nor when subjected to temperatures up to 175°F.**
 - 3. **Media shall be reinforced with multifilament fiber glass cord running parallel to the media length.**

4. The media shall be supported on both faces in the airstream by No. 8 wire rods parallel to the direction of media travel. Rod spacing shall be on not more than 3" centers on the air leaving face and on not more than 6" centers on the air entering face.
 5. The roll media shall be UL-listed and classified Class 2 when tested in accordance with UL 900.
 6. Filter media shall be tested by an independent test laboratory in accordance with ASHRAE Standard 52 as outlined in Section 11.2 Dynamic Procedure for Self-Renewable Devices. The performance of the filter media shall not be less than the following based on a velocity of 500 fpm: Initial resistance of 0.18" w.g., average synthetic duct weight arrestance of 83%, and dust holding capacity of 98 grams per square foot.
- E. **Operator/Controls:** The filter assembly operator and controls shall be completely factory-assembled and prewired, with the only field-wiring required being the 120 volt power supply to the control box.
1. Each filter shall be complete with initial loading of filter media and a 1/6 hp, 120 volt, 1-phase gear motor with thermal overload protection and chain drive, NEMA 1 control box containing a low voltage transformer for the photoelectric media control circuit, warning light and dry alarm contact to indicate either supply lamp failure or media runout, and hand-off-auto selector switch. The alarm contact shall be monitored by [_____].
 2. The controls shall be factory-wired and interconnected electrically to ensure fail safe operation. All factory and field wiring shall meet the requirements of the National Electrical Code.
 3. The drive motor shall be actuated by a photo-electric solid state control which shall cause the media to be advanced in small increments when and only as dust accumulation dictates.
 4. The control circuit shall ensure that no media is fed when the system is inoperative, shall feed the uniform small increments of media for constant dirt load and shall not require recalibration if the actual start-up airflow is different from design or if the system is of the variable air volume type.
- F. **Manufacturers:** Roll filter assemblies shall be American Air Filter Roll-O-Matic or an approved equal.

2.4 FILTER MANOMETERS:

- A. **[General:** Provide a Dwyer 200 Series "Dura-Block" solid plastic, stationary inclined gauge manometer with red gauge oil for each filter bank of each air handling unit. Provide not less than 2 ounces of red gauge oil for replacement of each manometer furnished under this Section.]

[OR]

- B. **[General:** Provide filter manometers for each individual filter or filter bank handling [2,000 [_____] cfm or more and each high efficiency filter. Manometers shall be diaphragm-actuated dial and pointer type magnahelic filter pressure drop gauges mounted on the unit exterior. Gauges installed on filters installed in finished areas shall be flush-mounted. All gauges for a single filter housing shall be mounted in a single group on the unit exterior in an accessible location as the unit is installed and shall have an engraved nameplate identifying the filter monitored. Gauges shall be Dwyer Model No. 2003-AF (0-3" w.g. range) or an approved equal. [A Dwyer Model No. 1823-5 differential pressure switch or an approved equal with No. A-603 "T" kit shall be furnished and installed with each magnahelic gauge for remote monitoring by the BCAS. The differential pressure switch shall be set as recommended by the filter manufacturer.] The magnahelic gauge shall be provided with red and green scale overlays located on highlight safe and dangerous readings as recommended by the filter manufacturer.]

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install filter racks, housings, and filters in accordance with the manufacturers' written installation instruction.
- B. Coordination: This contractor shall coordinate equipment and filter bank connection requirements and provide transitions as required for proper installation of filters.

3.2 AIR FILTERS:

- A. General: Install all filters protecting equipment prior to unit startup. Under no circumstances shall any air handling unit or fan and coil unit which is shown or specified to be furnished with filters be operated without filters in-place. Filters on units used during construction shall be replaced as necessary and as directed by General Contractor.
- B. Coil Cleaning: In the event that units are operated without filters in-place or with filters which have been damaged so as to allow air to bypass filter, the Contractor shall steam clean all coils and fans in that particular system before balancing the system.
- C. Filter Sizes: In all cases, filters shall be of the proper size and installed in filter racks in such a manner that there will be no leakage of air around filters. Filters which have been torn, distorted, or damaged in any other way will not be acceptable.
- D. Temporary Prefilters: Provide blanket insulation or roll filter media over pleated filters as temporary prefilter during construction.
- E. Testing and Balancing: All testing and balancing of air-side systems shall be done using clean filters. Where required, filters which have been used, shall be replaced prior to testing and balancing of air systems.
- F. Clean Filters: Upon completion of the project and before final acceptance, all disposable media filters shall be replaced with new media.
- G. Spare Filters: Furnish one complete stock of replacement filters and media, sufficient to replace all filters on the project, to the Owner for maintenance use. Filters shall be delivered in their original, unopened containers, and stored as directed by the Owner.

3.3 FILTER MANOMETERS:

- A. General: Install filters manometers **[and differential pressure switches]** per the manufacturers' written installation instructions. Where multiple filter banks (e.g. prefilters and final filters) are installed, individual manometers **[and differential pressure switches]** shall be provided for each filter bank.
- B. Differential Pressure Switches: Coordinate remote monitoring connections for filter differential pressure switches with the Building Control and Automation System (BCAS) furnished under **[Division 23]**.
- C. Gauge Oil: Provide extra red gauge oil in original, unopened containers to the Owner for maintenance use.

END OF SECTION 23 40 00

SECTION 23 51 00 – BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Listed double-wall **[vents] [chimneys]**.
 - 2. Field-fabricated metal breechings **[and chimneys]**.
 - 3. Listed **[grease] [dishwasher] [grease and dishwasher]** ducts.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and Workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. NFPA: Comply with NFPA 211 "Standard for Chimneys, Fireplaces, Vents and Solid Fuel Burning Appliances".
 - 2. UL: Comply with applicable portions of UL safety standards; provide products which have been UL listed and labeled.
 - 3. SMACNA: Comply with SMACNA Low Pressure Duct Standards for fabricated breeching and smokepipe.
 - 4. AWS: Comply with AWS Structural Welding Code for welders' qualifications, welding details, and Workmanship standards.
 - 5. ASHRAE: Comply with the ASHRAE Equipment Handbook, Chapter 27, for Chimney, Gas Vent, and Fireplace Systems, material requirements and design criteria.

1.04 QUALITY ASSURANCE

- A. Source Limitations: Obtain listed system components through one source from a single manufacture.
- B. Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

- C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.05 SUBMITTALS

- A. Product Data: Furnish product data for the following:

1. Type B and BW vents.
2. Type L vents.
3. Special gas vents.
4. Building-heating-appliance chimneys.
5. Grease ducts.
6. Guy wires and connectors, and installation details.

- B. Record Documents:

1. Shop Drawings for vents, breechings, chimneys, and stacks. Include Drawings, elevations, Sections, details, and attachments to other Work.
2. Details equipment assemblies which indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and restraints, including the location and the size of each field connection.
3. For installed products indicated to comply with design loads, include calculations and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
4. Welding certificates.

1.06 DELIVERY, STORAGE AND HANDLING

- A. The Work of this Section shall be coordinated with other trades affecting, or affected by this Work, to assure the steady progress of all Work performed under the Contract.
- B. Replace any Sections or assemblies damaged during shipment, storage or handling with new identical factory-supplied components.
- C. Protect finishes from physical damage by leaving factory packing cases in place before installation and providing temporary protective covers after installation with on going construction within the Project Site.

1.07 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or Workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.
- B. Warranty Period: [10] [15] [25] <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. American Metal Products; MASCO Corporation.
- B. Metal-Fab, Inc.
- C. ProTech Systems Inc. (Special Gas Vent) (Grease Ducts).
- D. Heat-Fab Inc (Special Gas Vent) (Grease Ducts).
- E. Selkirk Inc.; Selkirk Air Mate.
- F. Simpson Dura-Vent Co., Inc.; Subsidiary of Simpson Manufacturing Co.
- G. Van-Packer Co.

2.03 LISTED TYPE B AND BW VENTS

- A. Description: Double-wall metal vents tested according to UL 441 and rated for [480 degrees F continuously for Type B], or [550 degrees F continuously for Type BW]; with neutral or negative flue pressure complying with NFPA 211 and suitable for certified gas-fired appliances.
- B. Construction: Inner shell and outer jacket separated by at least a 1/4-inch airspace.
- C. Inner Shell: [ASTM B 209, Type 1100 aluminum] [ASTM B 209, Type 3003 aluminum] [ASTM B 209, Type 3105 aluminum] [ASTM A 666, Type 430 stainless steel].
- D. Outer Jacket: [Galvanized] [Aluminized] steel.
- E. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight Sections; all listed for same assembly.
 - 1. Termination: Stack cap designed to exclude 90 percent of rainfall.
 - 2. Termination: Round chimney top designed to exclude 98 percent of rainfall.
 - 3. Termination: [Insert special type termination or delete this option from specification.]

2.04 LISTED TYPE L VENT

- A. Description: Double-wall metal vents tested according to UL 641 and rated for 570 degrees F continuously or 1700 degrees F for 10 minutes; with neutral or negative flue pressure complying with NFPA 211 and suitable for low-heat appliances.
- B. Construction: Inner shell and outer jacket separated by at least a [1/4-inch] [1-inch] [2-inch] [4-inch] airspace filled with high-temperature, [ceramic-fiber] [mineral-wool] insulation.
- C. Inner Shell: ASTM A 666, Type [304] [316] stainless steel.
- D. Outer Jacket: [Galvanized] [Aluminized] [Stainless] steel.
- E. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight Sections; all listed for same assembly.
 - 1. Termination: Stack cap designed to exclude 90 percent of rainfall

2. Termination: Round chimney top designed to exclude 98 percent of rainfall.
3. Termination: Exit cone with drain Section incorporated into riser.
4. Termination: [Insert special type termination or delete this option from specification.]

2.05 LISTED SPECIAL GAS VENT

A. Manufacturers:

1. Heat-Fab Inc.
2. Metal-Fab, Inc.
3. ProTech Systems Inc.
4. Z-FLEX.

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 degrees F continuously, with positive or negative flue pressure complying with NFPA 211 and suitable for condensing-gas appliances.

C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.

D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.

E. Outer Jacket: [Aluminized] [Stainless] steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight Sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude 98 percent of rainfall.
3. Termination: Exit cone with drain Section incorporated into riser.
4. Termination: [Insert special type termination or delete this option from specification.]

2.06 LISTED BUILDING-HEATING-APPLIANCE CHIMNEYS

A. Description: Double-wall metal vents tested according to UL 103 and rated for 1000 degrees F continuously or 1700 degrees F for 10 minutes; with neutral or negative flue pressure complying with NFPA 211 and suitable for dual-fuel boilers, oven vents, water heaters, or exhaust for engines.

B. Construction: Inner shell and outer jacket separated by at least a [1/2-inch] [1-inch] [2-inch] [3-inch] [4-inch] annular space [filled with high-temperature, ceramic-fiber insulation]

C. Inner Shell: ASTM A 666, Type [304] [316] stainless steel.

D. Description: Double-wall metal vents tested according to UL 103 and 959 and rated for 1400 degrees F continuously or 1800 degrees F for 10 minutes; with positive or negative flue pressure complying with NFPA 211 and suitable for dual-fuel boilers, oven vents, water heaters, or exhaust for engines.

E. Construction: Inner shell and outer jacket separated by at least a [1-inch] [2-inch] [3-inch] [4-inch] annular space filled with high-temperature, ceramic-fiber insulation.

- F. Inner Shell: ASTM A 666, Type [304] [316] stainless steel.
- G. Description: Double-wall metal vents tested according to UL 103 and rated for 1000 degrees F continuously, or 2100 degrees F for 10 minutes; with neutral or negative flue pressure complying with NFPA 211 and suitable for fireplaces and other solid-fuel-burning appliances
- H. Construction: Inner shell and outer jacket separated by at least a [1-inch] [1-1/2-inch] [2-inch] [4-inch] annular space filled with high-temperature, ceramic-fiber insulation.
- I. Inner Shell: [ASTM A 666, Type 304] [ASTM A 666, Type 316] [ASTM A 240/A 240M, Type 430] stainless steel.
- J. Outer Jacket: [Galvanized] [Aluminized] [Stainless] steel.
- K. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight Sections; all listed for same assembly.
 - 1. Termination: Stack cap designed to exclude 90 percent of rainfall.
 - 2. Termination: Round chimney top designed to exclude 98 percent of rainfall.
 - 3. Termination: Exit cone with drain Section incorporated into riser.
 - 4. Termination: [Insert special type termination or delete this option from specification.]

2.07 LISTED GREASE DUCTS

- A. Description: Double-wall metal vents tested according to UL 1978 and rated for 500 degrees F continuously, or 2000 degrees F for 30 minutes; with positive or negative duct pressure and suitable for Type I, commercial kitchen grease duct.
- B. Construction: Inner shell and outer jacket separated by at least a [1-inch] [2-inch] [3-inch] [4-inch] annular space filled with high-temperature, ceramic-fiber insulation.
- C. Inner Shell: ASTM A 666, Type [304] [316] stainless steel.
- D. Outer Jacket: [Aluminized] [Stainless] steel.
- E. Accessories: Tees, elbows, increasers, hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight Sections; all listed for same assembly. Include unique components required to comply with NFPA 96.

2.08 FIELD-FABRICATED METAL BREECHINGS AND CHIMNEYS

- A. Fabricate freestanding chimneys according to SMACNA's "Guide for Steel Stack Design and Construction." Design for minimum <feet> high and <Insert inches> in diameter.
- B. Fabricate breechings and chimneys from ASTM A 569/A 569M hot-rolled steel with continuously welded joints, complying with NFPA 211 for minimum metal thickness.
 - 1. Equal to or Less Than 1.069 Sq. Ft. or 14 Inches in Diameter: 0.053 inch.
 - 2. Up to 1.396 Sq. Ft. or 16 Inches in Diameter: 0.067 inch.
 - 3. Up to 1.7 Larger Than above: 0.123 inch.
 - 4. 64 Sq. Ft. or 18 Inches in Diameter: 0.093 inch.

- C. Fabricate chimneys and vent connectors from galvanized steel, complying with NFPA 211 for minimum metal thickness.
 - 1. Equal to or Less Than 6 Inches in Diameter: 0.019 inch.
 - 2. Up to 10 Inches in Diameter: 0.024 inch.
 - 3. Up to 16 Inches in Diameter: 0.029 inch.
 - 4. Larger Than above: 0.056 inch.
- D. Fabricate chimneys and vent connectors from ASTM B 209, Type 1100 or 3003, aluminum or stainless steel, complying with NFPA 211 for the following minimum metal thicknesses:
 - 1. Aluminum: 0.027 inch.
 - 2. Stainless Steel: 0.012 inch.
- E. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and it also incorporates a gasket seal.

2.09 GUYING AND BRACING MATERIALS

- A. Cable: [Three] [Four] <Insert number> galvanized, stranded wires of the following thickness:
 - 1. Minimum Cable Size: 1/4 inch in diameter.
 - 2. For stack ID sizes 4 to 15 Inches: use 5/16 inch.
 - 3. For stack ID sizes 18 to 24 Inches: use 3/8 inch.
 - 4. For stack ID sizes 27 to 30 Inches: use 7/16 inch.
 - 5. For stack ID sizes 33 to 36 Inches: use 1/2 inch.
 - 6. For stack ID sizes 39 to 48 Inches: use 9/16 inch.
 - 7. For stack ID sizes 51 to 60 Inches: use 5/8 inch.
- B. Pipe: [Two] [Three] <Insert number> galvanized steel, NPS 1-1/4.
- C. Angle Iron: [Two] [Three] <Insert number> galvanized steel, 2 by 2 by 0.25 inch.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions that may affect performance of Work.
- B. Contractor shall furnish supervision and provide labor for installation of the Work product. Contractor shall field check the Work product prior to start-up and commissioning of equipment or appliance connected to the Work product such as vents, breechings, chimneys, grease ducts or stacks.

3.02 INSTALLATION

- A. Vents and Chimneys:

1. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
 2. Seal between Sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
 3. Support vents at intervals recommended by the manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
 4. Properly slope breechings in accordance with manufacturer's or Architect/Engineer recommendations, and install condensate a drain connection at the lowest point and piped to nearest drain.
 5. Connect base Sections of chimneys to foundation using anchor lugs of size and number recommended by manufacturer or Architect/Engineer.
 6. Join Sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.
 7. Erect stacks plumb to finished tolerance of no more than [1, 1.5, 1.75] < Insert number> inch out of plumb from top to bottom.
- B. Field-Fabricated Breechings and Chimneys:
1. Suspend breechings and chimneys independent of their appliance connections.
 2. Install, support, and restrain according to manufacturer's or Architect/Engineers requirements.
 3. Align breechings at connections, with smooth internal surface and maximum 1/8-inch misalignment tolerance.
 4. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
 5. Support breechings and chimneys from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or beam clamps according to manufacturer's written instructions.

3.03 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.
- B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.
- C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or not completely connected to equipment or appliance.

END OF SECTION 23 51 00

SECTION 23 52 33 - HOT WATER BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

PART 1 - GENERAL

1.2 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.3 DESCRIPTION OF WORK:

- A. Work Included: Provide gas-fired hot water boilers as specified, scheduled, and indicated herein to maintain the design conditions within the heating hot water loop.

1.4 QUALITY ASSURANCE:

- A. Manufacturer: Provide boilers as manufactured by Ray Pak and A. O. Smith, or approved equal.

1.5 SUBMITTALS:

- A. Shop drawing submittals shall include, but not be limited to, the following:
 1. Boiler cut sheets with all capacities, characteristics, features, accessories and options clearly indicated.
 2. Published copies of ASME short form test proving capacities and certified guaranteed efficiency ratings of his equipment. Ratings shall accompany his shop drawings submittal, or the boiler manufacturer may perform ASME short form test at job site at his own expense.
 3. Additional information as required in Section 23 01 00.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver boiler in factory-fabricated water-resistant wrapping.
- B. Handle boiler carefully to avoid damage to material components, enclosure and finish.
- C. Store boiler in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. General: Provide complete packaged hot water boilers of the type, size, and capacities required.

2.2 GENERAL BOILER DESIGN:

- A. Requirements: Boiler shall be a horizontal fire-tube updraft boiler with a minimum of 5 square feet of heating surface per rated boiler horsepower. Boiler shall be mounted on a heavy steel frame with integral forced draft burner and burner controls. The complete packaged boiler shall be approved as a unit by Underwriters' Laboratories, Inc. (UL) and shall bear the UL label. The unit shall comply with all applicable sections of the ASME Boiler and Pressure Vessel Code and be suitably stamped.
- B. Packaged Unit: Boiler shall be completely preassembled and fire-tested at factory. Unit shall be ready for immediate mounting on floor or simple foundation and ready for attachment of water, fuel, electrical, and vent connections.

2.3 BOILER SHELL:

- A. General: Boiler shell shall be constructed in accordance with ASME Boiler Code and receive authorized boiler inspection prior to shipment. Provide a copy of the inspection report to the Construction Manager. Locate two lifting eyes on top of boiler.

- B. Doors: Front and rear doors on the boiler shall be hinged. Seal doors with tadpole gaskets and fasten tightly using heavy-duty capscrews which thread into replaceable brass nuts.
- C. Formed Door: Rear refractory and insulation shall be contained in the formed door which shall swing open for inspection of brick work.
- D. Inspection and Cleaning: Front and rear tube sheets and all flues shall be fully accessible for inspection or cleaning when the doors are swung open. Furnish shell with adequate handholes to facilitate boiler inspection and cleaning. Provide a manhole for boilers over 48" in diameter.
- E. Exhaust Vent: Exhaust gas vent shall be located near the front of boiler on top center line and shall contain a stack thermometer.
- F. Ports: Provide observation ports for inspection of flame conditions at each end of boiler.
- G. Insulation: Boiler insulation shall consist of a 2" fiberglass blanket under a sectional preformed sheet metal lagging. This insulation shall be readily removed and reinstalled, if required.
- H. Finish: Factory-paint entire boiler base frame and other components before shipment using a hard-finish enamel.

2.4 BOILER TRIM:

- A. Low Water Cutoff: Low water cutoff shall be an integral part of boiler control. Cutoff shall be wired in the burner control circuit to prevent burner operation if boiler water falls below a safe level. An auxiliary low water contact shall also provide remote annunciation at the Engineer's office.
- B. Gauge: Water temperature and pressure gauges shall be located at the front end of the boiler and shall include cock and test connection.
- C. Relief Valves: Provide safety relief valves of a type and size to comply with ASME Code requirements.
- D. Controls: Factory mount hot water temperature controls for regulation of burner operation.

2.5 FUEL BURNING AND FIRING EQUIPMENT:

- A. Burner: Burner, integral with the front head of boiler, shall be a high radiant multiport-type for gas. Burner shall be approved for operation with natural gas and be UL-labeled.
- B. Type of Burner Operation: Burner shall operate on the full modulation principle. Burner shall return to low fire position for ignition.
- C. Gas Pilot: Gas pilot shall be premix-type with automatic electric ignition. An electronic detector shall monitor pilot so that the primary fuel valve cannot open until pilot flame has been established.
- D. Forced Draft Blower: All air for combustion shall be supplied by a blower mounted in front of boiler door, above burner, and directly connected to a flanged-type motor. This rigid mounting with the blower wheel inside the head shall eliminate all vibration and reduce noise level. Balanced blower wheel shall be cast aluminum with radial blades.
- E. Combustion Air Control: Combustion air damper and cam-operated fuel-metering valve shall operate by a single damper control motor which regulates the fire according to load demand. Potentiometer-type positioning controls shall regulate operation of damper control motor.
- F. Gas System: Gas burner shall be of the multiple-jet, flame retention type with the following features:
 - 1. A main gas control group consisting of an automatic motorized gas valve, automatic safety gas valve, gas volume control valve with adjustable cam operator, gas pressure regulator, gas gauge, gas cock, gas/ electric ignition assembly consisting of a pilot burner, 6,000 volt ignition transformer, flame rod, airflow safety switch, ultraviolet or lead sulfide flame detector, and low fire start.
- G. Modular Control Panel: Control panel shall be mounted at eye level height on the front door of the boiler. Provide hinged metal cabinet, NEMA I enclosure with neoprene dust seal and Yale cabinet key lock. This panel shall contain the electronic programming relay, FVNR blower motor starter, self-locking plug-in fuel modules, four indicating lights, and the control switches. Indicating lights and switches shall be mounted in a separate hinged drop-panel for easy access to all wiring.

1. The programming relay shall control the ignition timing, starting and stopping of burner, a precombustion purge, and post-combustion purge. Through a flame scanner, the relay shall shutdown the burner in the event of ignition, pilot, or main flame failure.
2. A manual-automatic selector switch and damper motor positioning switch shall be provided on all units. These switches shall permit automatic firing in accordance with load demand or manual control of the firing rate and any desired point between low fire and maximum rating.
3. Four indicating lights shall show operating conditions of: red - low water level; red - flame failure; white - fuel valve open; white - load demand.
4. All electrical equipment shall be wired in conformance with UL requirements. Oil, heat, and moisture-resistant wire shall be used throughout.
5. Control circuit transformer shall be mounted in control panel.

2.6 EFFICIENCY GUARANTEES:

- A. General: Boiler shall be guaranteed to operate at a minimum fuel-to-hot water efficiency of 80% from 30 to 100% of rating.

2.7 SHOP TESTS:

- A. General: Packaged boiler shall receive factory tests to check construction, control, and operation of unit.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: The boiler shall be installed in accordance with the manufacturer's instructions and prevailing state, county, and local codes.
- B. Pipe relief valve, drain and blow-down discharge to 4" above floor drain.
- C. The Electrical Contractor will provide power wiring to the control cabinets. The unit shall have relays for future connection to the energy management system.

3.2 MANUFACTURER'S SERVICES AND FIELD QUALITY CONTROL:

- A. General: The boiler manufacturer's authorized factory-trained technician shall inspect the boiler installation, ascertain that the boiler and supporting systems have been installed in compliance with the boiler manufacturer's instructions, perform start-up, make adjustments, and write a letter on boiler manufacturer's letterhead stating that the installation is in compliance with manufacturer's instructions and that the boiler is operating properly. This technician shall devote two 8 hour days instructing the Owner's operating personnel at a time designated by the Owner.
- B. Warranty: The entire unit and components shall have a minimum one year guarantee.
- C. Start-up Service: Entire unit shall have a start-up service and one year service period by factory-trained personnel.

END OF SECTION 23 52 33

SECTION 23 57 10 – CLEAN STEAM GENERATORS AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.3 DESCRIPTION OF WORK:

- A. Work Included: Provide unfired steam generators as specified, scheduled, and indicated herein to provide clean steam supply to the building.

1.4 QUALITY ASSURANCE:

- A. Manufacturer: Provide clean steam generators as manufactured by RECO USA, DHT, Heat & Power, Inc., or approved equal.

1.5 SUBMITTALS:

- A. Shop drawing submittals shall include, but not be limited to, the following:
 - 1. Clean Steam Generator
Design Data; Data Sheets, Wiring Diagrams, Piping Diagrams
Clean Steam Generator: Heating surface and volume measurements, Heat release calculations, Performance data at minimum, 25 percent, 50 percent, 75 percent, and 100 percent load.
Control Module
[Boiler feed Unit]
Analog Boiler Controller
[Clean Steam Piping]
[Clean Steam Condensate Piping]
 - 2. Submit evidence that the clean steam generator meets the requirements of standards specified. Include with the certificate of compliance acceptable evidence that standards are met. Acceptable evidence will be the official UL listing mark prescribed in the UL gas and oil equipment list for oil-fired, or gas and oil-fired boiler assemblies, as applicable plus the appropriate official ASME symbol stamp. In lieu of the above certification, acceptable evidence will be a test report from an independent testing laboratory, indicating that the boilers and accessories have been inspected and tested and meet requirements of the applicable standards specified.
 - 3. Additional information as required in Section 23 01 00.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver unfired steam generator in factory-fabricated water-resistant wrapping.
- B. Handle boiler carefully to avoid damage to material components, enclosure and finish.
- C. Store unfired steam generator in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. General: Furnish materials, equipment, and labor to install clean steam generator packages as shown on drawings and specified herein. Provide complete packaged clean steam generators of the type, size, and capacities required.

2.2 GENERAL CLEAN STEAM GENERATOR DESIGN:

- A. Clean steam generators shall be a horizontal or vertical configuration as specified on the drawings. The unfired steam generators shall be ASME code constructed and stamped for unfired steam generators. Unfired steam generators shall be registered with the National Board and Pressure Vessel Inspectors, and signed copy of the shop inspection report shall be furnished to the Owner. Unfired steam generators shall be built in accordance with unfired steam generators rated for 150 psig working pressure. The complete packaged unfired steam generators shall be approved as a unit by Underwriters' Laboratories, Inc. (UL) and shall bear the UL label. The unit shall comply with all applicable sections of the ASME Boiler and Pressure Vessel Code and be suitably stamped.
- B. Boiler shall be completely preassembled and fire-tested at factory. Unit shall be ready for immediate mounting on floor or simple foundation and ready for attachment of water, fuel, electrical, and vent connections.
- C. The generators and all components subject to steam side shall be 316-L grade stainless steel.
- D. The generators shall be insulated with not less than **[3"]** of fiberglass insulation which shall be protected by not less than **[20]** ga. thick enameled steel jacket.
- E. The generators shall be mounted on a suitable I-beam support skid, which shall be permanently mounted to the shell.
- F. The generators shall have a submerged coil of 316 stainless steel tubes expanded into a 316 stainless steel tube sheet with cast iron heads.
- G. The generators shall be furnished with an electric operated control valve to modulate the incoming steam to maintain the desired output of steam **[+2 psig]**. The control valve shall be suitable for **[150]** psig. The equipment control shall monitor output steam pressure and modulate the steam valve to maintain constant output pressure.
- H. The generators shall be factory supplied with dual float and thermostatic traps, one for the coil and one for the drip before the control valve. The generators shall have an incoming strainer.
- I. The generators shall be furnished with an ASME Code pressure relief valve or valves with a capacity to relief the total BTU of output of the generators.
- J. The generators shall be furnished with a vessel steam gauge, electronic level controller, and the water column shall be furnished with gauge glass. The generators shall be furnished with tandem blow off valves.
- K. All components for the unfired steam generators shall be factory mounted, piped, and tested and the units shall be shipped from the factory as complete packages ready for installation. The units shall be furnished with steam separators.
- L. The generators shall be supplied with solid-state control modules with LED backlit LCD displays and LED pilot lights to indicate on/off, high pressure, low pressure, low water, and water feed. Solid-state control modules shall allow the Owner to set pressure limits on the display screen.
- M. The solid-state control module shall have a flashing red alarm light and alarm horn with built-in alarm silence relay. **[Solid-state control modules shall be supplied with dry contact closure outputs to indicate building automation controls (BACS), the occurrence of power on, high pressure, low pressure, low water, and water feed. The control module shall allow the BACS to turn the unfired steam generator on or off through a remote relay suitable for 24 VAC, 1 amp. The control module shall allow the BACS to remotely monitor the operating pressure]**. The control module shall be supplied with an on/off switch and shall be mounted in a NEMA 1 panel. All solenoids and limits shall be 24 VAC.
- N. When the level sensor calls for feed water, the boiler feed pumps shall turn on as indicated by the sequence of operations.
- O. The steam generator packages shall include a vacuum breaker.
- P. The steam generator packages shall include an alarm bell and light to signal low water or high pressure. Alarm silence relay shall be provided to silence the bell but not the light.
- Q. The steam generator packages shall be provided with relays with 120-volt coils to remotely start or stop the generators.

- R. The steam generator packages shall be equipped with a conductivity controlled automatic blow-down, set to maintain purity of less than **[1500]** ppm total dissolved solids (TDS) in the clean steam system.
- S. The blow-down discharge shall be piped to a new blow-down separator.
- T. The steam generator packages shall include a centrifugal blow off condensate cooler.
- U. The high pressure condensate from the clean steam generator shall discharge to a flash tank producing low pressure condensate and low pressure flash steam.
- V. The steam generators shall be factory-furnished with high water shut-off. High water shut-off shall include an electronic probe mounted in the top of the unit connected to an electric operated power to open spring to close ball valve. In the event of high water, the ball valve shall close..

2.3 CLEAN STEAM GENERATOR CONNECTIONS:

- A. Requirements for interconnecting piping, insulation, steam supply, vibration isolation, and other related work necessary to provide a complete and operable steam system, whether or not specifically mentioned above, shall conform to applicable requirements of other sections of Division 15. Clean steam generator shall be completely packaged and skid mounted with all necessary instrument controls, arranged for single point connection for all utilities.

2.4 CLEAN STEAM GENERATOR CONTROL MODULE:

- A. Provide Solid State Steam Control Module with the following features:
 1. Remote start/stop.
 2. On/Off switch.
 3. Alarm horn with alarm silence relay.
 4. Low water cut-off.
 5. Timer for timed blow-down.
 6. Relay for water feed.
 7. Operating pressure readout LCD display.
 8. High pressure cut-out and alarm.
 9. Low pressure alarm.
 10. LED Display of functions: power on, low water, high water, low pressure, high pressure, blow-down operating, water feed.
 11. **[Contacts to notify building automation system (BACS) of functions and alarms: power on, low water, high water, low pressure, high pressure, blow-down operating, water feed, operating pressure, any alarm.]**
 12. **[The input shall be 120 VAC, 60 Hz. The output contact shall be 1 amp at 24 VAC. The BACS outputs shall be dry contacts, NO/NC, 0.5 amp maximum, non-inductive. The display shall be LED with a resolution of 0.3% of scale.]**
 13. **[The available pressure ranges shall be 0-30, 0-60, and 0-150.]**
 14. **[The unit shall operate within the following ambient temperature range: min 32 degrees F to a maximum of 140 degrees F. The operating humidity shall be 5%-95% relative humidity non-condensing.]**
 15. The unit shall be provided in a **[NEMA 4]** enclosure.
 16. **[Contacts to notify BACS of functions and alarms: power on, low water, high water, low pressure, high pressure, blow down operating, water feed, operating pressure, any alarm.]**

2.5 CABINETS:

- A. Provide steam generator control and instrument cabinet (s) and mount either on the steam generator front(s) or adjacent thereto. The arrangement may consist of steam generator mounted cabinet containing controls normally provided by the manufacturer and a supplementary cabinet containing additional controls and instruments required herein.

2.6 CONTROL PANEL CONSTRUCTION:

- A. Construct control panel of not less than 11 gage reinforced steel for face, top, and sides. The enclosed panel shall not less than 24 inches in depth with inside rigidly welded braces. Design control panel so that all indicating and recording devices and manually operated switches shall be flush mounted in a gasketed removable-top front panel with indicating and recording devices at eye-level. Provide a similar removable-top rear panel located opposite front panel to facilitate wiring, piping, and maintenance. Install other operating controls on a sub-panel within the enclosure. Access to panel enclosure shall be through gasketed, double piano-hinged doors of not less than 16 gage steel. The doors shall be reinforced to prevent sagging and shall be provided with a three point compression type fastener and polished key lock handle. Include a full width fluorescent lighting canopy also. Prime coat complete control panel and lighting canopy also. Prime coat complete control panel and lighting canopy and finished in baked enamel. Identify flush-mounted devices on panel with engraved lamcore nameplates. Adequately reinforce, skirt, and suitably design panel base to permit anchoring to the floor or foundation.

2.7 CONTROL PANEL WIRING AND PIPING:

- A. Control panel shall be factory pre-wired in accordance with NFPA 70. Wire shall be thermoplastic Type THW, THWN, XHHW, or UL approve for the intended use, color or number coded, and run in plastic ducts to numbered terminal blocks. Control circuits shall be separately fused with properly rated cartridge type fuses. Power leads to and from magnetic starters and contractors shall terminate at terminal blocks so that field wiring is necessary only from terminal blocks to external equipment. Control leads to and from external control devices shall terminate at separate terminal blocks from power leads. Steam, draft, and air operated devices shall be factory piped to permanently affixed external connections. Pneumatic signals shall be either 3 to 15 psig or 3 to 30 psig. Piping connections to indicators shall be copper tubing conforming to ASTM B 88. The boiler operating switch shall be a dust-tight sealed snap-action type. The precision switches shall have cadmium, silver, or platinum contacts, wiring action type, rated at 10 amperes. Electrically or pneumatically tested, controls and equipment shall be to simulate complete operational sequence.

2.8 **[INSTRUMENTATION:]**

- A. **[Provide a steam flow recorder: to remotely indicate, record and totaling the steam flow per hour through the steam header. Provide the panel-mounted indicating feed water pressure.]**

2.9 **[BOILER FEED UNIT:**

- A. **Provide a tri-plex (3-pump) pumping boiler feed unit, ITT Industries, Bell & Gossett, Domestic Series, Seller or approved equal. The boiler feed unit shall include tanks, pumps, etc. and shall completely of stainless steel construction. The boiler feed unit shall have the following features:**
- 1. The unit shall be provided as a complete factory-assembled package.**
 - 2. The unit shall have horizontal welded stainless steel receiver, minimum 3/16" thickness with dished heads and inlet cascade baffle. The receiver shall be sized for 10 minute net storage of system water requirements.**
 - 3. The unit shall have gauge glass with a shutoff valve, dial thermometer, and low level cut-off float switch.**
 - 4. The unit shall be provided with centrifugal pumps with open drip-proof motors. The pump capacity shall be sized for 2 times the system return rate. The pumps shall be stainless steel.**
 - 5. The unit shall have a float switch, 3/4" or 1" solenoid valve and "Y" strainer water make-up assembly.**
 - 6. The receiver shall have an inlet, vent and an overflow opening to provide means of secondary venting.**
 - 7. A suction isolation valve shall be installed between each pump suction and receiver to permit servicing of the pumps without draining the receiver.**

8. **The receiver shall be provided with lifting eye bolts, companion flanges, stainless steel inlet strainer with vertical self-cleaning stainless steel screen and large dirt pocket. The screen shall be easily removable for cleaning, requiring no additional floor space for servicing.**
9. **The unit shall also include the following items (all internal components shall be stainless steel): inlet basket strainer, suction butterfly valves, manhole, NEMA 2 UL Listed controls panels, manual bypass assembly around solenoid water make-up valve, discharge pressure gauges, and high and low water alarms and required controls, and sparging tube. The feed water shall be pre-heated to 160 degrees F by introducing low pressure steam through the sparging tube, as indicated.**
10. **The water pumps shall be two-staged, centrifugal design, stainless steel construction, permanently aligned and flanged mounted for vertical operation. Each pump shall be sized for 2 times the boiler evaporation rate.**
11. **Each pump shall be close-coupled to a 3500 rpm, vertical, drip-proof motor and shall deliver its full capacity with condensate temperatures up to 210 degrees F at sea level, at 2 ft. NPSH. The carbon/ceramic mechanical shaft seal shall be rated for 250 degrees F.**
12. **Each pump shall include: axial flow first stage dynamically balanced impeller, straightening vanes, renewable case ring, shaft, discharge gauge port tapping, and drain tapping.**
13. **The water make-up assembly shall be installed on the receiver of capacity equal to one boiler feed pump. The assembly shall consist of; level control switch, electric solenoid valve (packless, piston pilot-operated type with cushioned closing feature and epoxy resin molded water proof coil and a manual bypass.)**
14. **The unit shall be sized for [XXXXXXXX sq.ft EDR], [XXXXX lbs/hr], [XX gpm], and a pump discharge pressure of [XXX psig].**
15. **The control panel shall be a mounted and wired NEMA 2 control cabinet with drip lip and piano hinged door enclosing the following: combination magnetic contactor with adjustable thermal overload protection with fused disconnect and cover interlock for each pump, HOA selector switch for each pump, numbered terminal strip, fused control circuit transformer when the voltage exceeds 230 V, and a pump running light for each pump.**
16. **The control panel shall be equipped with all control points as listed in the design drawings.]**

2.10 ANALOG BOILER CONTROLLER:

- A. The Contractor shall provide and install a analog boiler controller, or approved equal. The controller, or approved equal, shall be used to control total dissolved solids in the steam generating system:
 1. The controller shall be used conductivity timed samples to determine blow-down and shall be provided with a blow down valve, solenoid and strainer or motor operated ball valve, needle valve or orifice union and plates for throttling blow down, a full-port gate valve for isolation of blow down assembly, and a flush valve for the sensor.
 2. A flow rate of a least **[1]** gpm is required at the electrode for proper operation. Hand valves shall be installed on both sides of the electrode to relieve pressure at the electrode for easy removal and period maintenance.
 3. The specified controller is configured to physically separate the low and high voltage connections. Use only 16 or 18 AWG wire for conduit power and load connections.
 4. The controller panel shall include the following: control LED, power LED, calibration adjustment knob, test switch, and set/read switch, trip point knob, analog scale, and range switch.

2.11 BOILER BLOW DOWN SEPARATOR:

- A. Provide As indicated, boiler blow-down separators with the following features:

1. The tank shall be constructed of 316 stainless steel with tangential inlet pipe and stainless steel striking plate, vent opening, discharge opening with spiral formed discharge directing plate, supported on 3 legs of indicated height.
2. Provide a cold water inlet in the discharge pipe and 2 thermometer wells.
3. Provide a temperature regulating valve in the water inlet with a temperature sensing bulb in lower thermometer well, bi-metallic thermometer in upper thermometer well, and Y-type strainer in cold water inlet line upstream of temperature regulating valve. Provide backflow prevention device in water inlet.
4. The boiler blow down separator shall be equipped with a thermostatically controlled domestic cold water connection as well as an auxiliary line piped from the new Reverse Osmosis (RO) water system providing a continuous blow-down of **[8 gpm of 500 ppm]** TDS water. The **[8 gpm RO water blow-down]** should be sufficient to properly cool the clean steam generator blow-down discharge. In a shortage of cooling however, the thermostatically controlled domestic water shall provide supplemental cooling. The clean steam generator blow-down discharge shall be cooled to at least **[140 degrees F]** before discharging into the building drainage system.
5. Available manufacturers: **[Cemline, Penn Separator Corp., Wessels Co., York Shipley, Inc.,]** or approved equal.

2.12 **[FLASH TANK:**

A. Provide a flash tank, as indicated, with the following:

1. **The tank shall be ASME code constructed and stamped for 150 lb. working pressure with 150 psig flanges.**
2. **Available manufacturers: Cemline, Penn Separator Corp., Wessels Co., York Shipley, Inc., or approved equal.]**

2.13 CLEAN STEAM SUPPLY PIPING:

- A. Clean steam piping shall be designed for a minimum service pressure of **[80 psig]** at **[250 degrees F.]** and be manufactured of Type 316 Stainless Steel conforming of ASTM A269 & A270. Tubing shall be fully annealed after welding. Tubing wall thickness shall be as follows:
 - B. Tube Size Wall Thickness
 - 1/4" OD 0.035"
 - 3/8" OD 0.035"
 - 1/2" through 3" OD 0.065"
 - 4" OD 0.083"
- C. Clean Steam tubing shall be finished as follows:
 1. Interior finish shall be standard mill finish.
 2. Exterior finish shall be standard mill finish, except where un-insulated and exposed to view in finished, sanitary and classified areas. In these areas, exterior finish shall be 180 grit mechanical polished.
- D. Available manufacturers: **[Colt Industries, Trent Tube Division, All-Tube Corp., Rath, United Industries,]** or approved equal.

2.14 BASIC PIPE FITTINGS:

- A. Provide tube fittings complying with the requirements of this section as follows:
 1. Fittings: Clean steam and clean steam condensate tube fittings shall be suitable for fabrication into the system by the tank shall be ASME code constructed and stamped for **[150 lb.]** working pressure with **[150 psig]** flanges.
 2. Joints: Only automatic machine butt-welded and Tri-Clamp type joints shall be provided. Tri-Clamp type joints shall be used when connecting to valves, equipment, and accessories with Tri-Clamp type ends; otherwise, joints shall be automatic machine butt-welded. Exceptions shall be shown on the drawings. Flange type joints shall be provided only when absolutely necessary to

mate up to flanged appurtenance. Threaded joints shall be provided only where Tri-Clamp to threaded adapters are indicated on the drawings. Teflon tapes shall be used on male pipe threaded joints. Pipe dope will not be permitted.

3. Clamps: Tri-Clamp type for use in connecting to fittings, valves, equipment, and accessories with Tri-Clamp type ends.
 - a. ½" thru ¾" – Type 304 stainless steel, two segment, heavy construction with metal wing nut as manufactured by **[Tri-Clover, Inc.]**
 - b. 1" thru 4" – Type 304 stainless steel, two piece high pressure cast clam with Type 304 stainless steel bolts and aluminum-bronze nuts as manufactured by **[Tri-Clover, Inc.]**
4. Gaskets (For Tri-Clamps specified above): For sizes less than 1" – provide flange molded one piece gasket of steam-resistant Viton as manufactured by **[Ladish Co., Tri-Clover division]**. For sizes 1" and greater, provide steam resistant Teflon envelope gasket with PTFE outer jacket and Viton rubber insert as manufactured by **[Ladish Co., Tri-Clover division]**.
5. Manufacturers: Fittings shall be as manufactured in strict accordance with all product standards established for sanitary piping systems. All fittings shall be furnished by a sole manufacturer, and the mixing of different manufacturers in order to supply the necessary quantity of fittings required for the complete and entire Clean Steam systems installation is expressly prohibited and unacceptable.
6. Fittings manufactured by the following supplier are acceptable: **[Ladish Co. Inc., Tri-Clover Division, Valex Corporation, Cherry Burrell Corporation, TCI-Superior, Inc., ITT-Sherotec, Rober-James Sales, Inc.,]**or approved equal.

2.15 PRESSURE GAUGES:

- A. Provide pressure gauges complying with the requirements of this section as follows:
 1. Pressure Gauges: Pressure Gauges shall be sanitary pharmaceutical design, glycerine filled, with stainless steel diaphragm, 3" diameter dial, 0-100 PSIG range, back or stem connection of sanitary clamp design.
 2. Pressure gauges manufactured by the following suppliers are acceptable: **[Ladish Co. Inc., Tri-Clover Division, Valex Corporation, Andersen Corporation, TCI-Superior, Inc., or approved equal.]**

2.16 BALL VALVES:

- A. Provide valves in sizes and numbers as indicated on the drawings and schedules, complying with the requirements of this section as follows:
 1. Ball valves with 316 stainless steel tube I.D. full-port ball, 316 stainless steel stem, and 316L stainless steel body, with Tri-Clamp ends to match ferrules to which they are attached, TFE seat, packing and cavity filler, USDA approved, manual operation, stem extensions, 400 psig max. WP. Finish shall be same as finish specified for tubing. Maximum working temperature 4" and smaller 450 degree F. **[Pittsburgh Brass Manufacturing SP Series.]**

2.17 CHECK VALVES:

- A. ½" and ¾" – Spring loaded plug check valves with Type 316L (low carbon) stainless steel body, Viton plug and body gasket. Type 316 stainless steel spring, Type 304 stainless steel body clamp, Tri-Clamp type ends to match ferrules to which they are attached, finish same as specified for tubing, 230 psig – 72 degree F, 100 psig – 250 degree F, **[Tri-Clover, Inc. C45MPS.]**
- B. 1" thru 2-1/2" – Spring loaded disc check valves with type 316L (low carbon) stainless steel body, Viton body gasket, Type 316 stainless steel spider, spring, and disc, Type 304 stainless steel body clamp, Tri-Clamp type ends to match ferrules to which they are attached, finish same as specified for tubing, 150 psig – 70 degree F, 125 psig – 250 degree F, **[Tri-Clover, Inc. B45MP.]**

2.18 STEAM TRAPS:

- A. Provide thermostatic type steam trap(s) on pure steam system as shown on the drawings.

1. Acceptable manufacturers include; [**Spirax Sarco, Inc. – Thermostatic Type BT-6, Nickolson Division of Dartron Systems, Inc.,**] or approved equal.
2. Steam trap shall be designed in conformance with 3-A sanitary fitting standards.
3. Unit body, inlet side and outlet side, and elements shall be type 316L (low carbon) stainless steel. Unit two-part body shall be sealed with PTFE gasket sandwiched between inlet and outlet sides. Body Tri-Clamp shall be type 304 stainless steel two-piece, bolted high pressure cast clamp. Unit shall have polished type 316L stainless steel construction with internal finish of 180 grit. Unit shall have Tri-Clamp inlet and outlet connections with sizes shown on drawings.
4. Unit shall be rated for maximum allowable pressure of 145 psi and maximum allowable temperature of 350 deg. F.
5. Element shall have liquid filling with boiling point for operation approximately 10 degrees F below saturated steam temperature.
6. Unit shall be self-draining when installed in vertical position as directed by manufacturer

2.19 NOISE LEVELS:

- A. Noise measurements and exposure analyses should be conducted under the overall supervision of an industrial hygienist. Safety personnel engineers and others who have been approved by the Owner also may supervise the work. Maintain exposure limits of **[60]** dBA at the equipment and **[40]** dBA within lab areas. The sound level meter shall conform as a minimum to the Type 2 requirements cited in ANSI S1.4.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Arrange work in a neat and orderly manner so that minimum storage of equipment and material is required at the project site. Install equipment and material in accordance with the best commercial practices. A competent installation engineer or technician as stated in paragraph "Qualifications of Engineer" shall assemble an unassembled steam generator package in strict accordance with the manufacturer's instructions. Systems shall be neat in appearance, compact, adequate in construction and assembly, and installed for long and continuous service. Parts shall be readily accessible for inspection, repair, and renewal. Inspect equipment and material upon delivery and test after installation. Protect material and equipment from the weather. Repair damage caused by the Contractor in execution of the work and leave in a condition equal to that existing before work was started.
- B. Equipment foundations locate as shown and construct of sufficient size weight and of proper design to preclude shifting of equipment under operating conditions or under abnormal conditions that could be imposed upon the equipment. Foundations shall meet requirements of equipment manufacturer. Grout equipment mounted on concrete foundations before installing piping. Install piping in such a manner so as not to place a strain on equipment.
- C. Welding work shall be accordance with applicable sections 23 01 00 and 23 03 00.
- D. Painting equipment shall be factory finished to withstand the intended end use environment in accordance with the specifications for the particular end item. Field paint equipment not factory finished as directed by Owner or specified herein. Retouch damaged areas of factory-finished equipment on which the finish has been damaged and then give a complete finish coat to restore the finish to it's original condition. The finish coat shall be suitable for exposure in the intended end use environment.
- E. Cleaning and application to remove dirt, rust, oil, and grease by wire brushing and solvent degreasing prior to application of paint. Apply paint to clean and dry surfaces only. Where more than one coat of paint is specified, apply the second coat after the first coat is thoroughly dry. Retouch damaged painting before applying the succeeding coat. Finished surfaces shall be smooth. The painting of zinc coated and other corrosion-resistant metal surfaces is not required unless otherwise specified herein.
- F. Control module installation, operation, and maintenance procedures shall be performed by trained/certified personnel. All personnel performing these procedures should completely and carefully read and understand product literature before attempting installation, and maintenance procedures.

Personnel shall be trained in and familiar with correct piping and electrical procedures and methods, and should be experienced in working with hot boiler water systems and steam systems.

- G. [Boiler feed unit shall be installed in accordance with the manufacturer's instructions. Power wiring, as required, shall be the responsibility of the Contractor. All wiring shall be performed per the manufacturer's instructions and applicable state, federal, and local codes. All factory wiring shall be numbered for easy identification and the numbers shall coincide with those shown on the wiring diagram. All interconnecting wiring between the pump controls and control panel shall be enclosed in liquid tight flexible conduit. The unit shall be factory tested as a complete package and the unit manufacturer shall provide elementary and connection wiring diagrams, piping diagrams, installation and operation instructions. The unit manufacturer shall furnish, mount on the unit, and wire a NEMA 2 control cabinet with drip lip and piano hinged door. A certified test report shall be provided by the factory.]**
- H. Analog boiler controller shall be mounted in a location convenient to electrical and plumbing connections and easily accessible by the operator for cleaning and maintenance. Installation shall comply with all local, state, and national codes. The controller shall be mounted vertically on a wall or a permanent vertical support with adequate lighting and a comfortable height for accessibility. Installation shall be in accordance with the manufacturer's instructions.
- I. Steam generator cleaning after installation, each steam generator shall be boiled out, under supervision of the manufacturer, with soda ash or equivalent solution to clean internal surfaces of oil, grease, mill scale, and dirt. Following treatment, the generators shall be flushed, drained and then opened and washed down and inspected to ensure that no traces of oil or foreign matter are present. The steam generators and associated piping shall then be drained and refilled with treated softened water. At all times after initial cleaning, the Contractor shall protect the steam generators, tank, and piping against internal corrosion until testing is completed and the steam generators are accepted. Provide chemicals, labor for introducing chemicals, and professional services for control and supervision of the treatment process.
- 3.2 FIELD QUALITY CONTROL:
- A. Perform inspections and tests as specified herein to demonstrate that the steam generators and auxiliary equipment, as installed, are in compliance with contract requirements. During steam generator system start-up tests, factory-trained engineers or technicians employed by individual suppliers of such components as the feed water treatment equipment, and other auxiliary equipment shall be present, as required, to ensure the proper functioning, adjustment, and testing of individual components and systems. No bypassing, use of jumpers, or other disablement of control systems will be allowed unless specified elsewhere. Labor, equipment, and test apparatus required for testing shall be furnished by the Contractor. Rectify defects disclosed by the tests by the Contractor within time period specified by the Owner.
- B. Inspection and tests make inspections and tests at the site under direction of and subject to the approval of the Owner. The Contractor shall operate each steam generator and appurtenances prior to final testing and shall ensure that necessary adjustments have been made. A 48-hour written notice shall be submitted to the Owner indicating the equipment is ready for inspection and testing. Provide testing equipment, including gages, thermometers, calorimeter, Orsat apparatus, thermocouple pyrometers, water meters, and other test apparatus and set up and calibrate prior to the test. Steam flow may be measured by permanent gages and meters installed under the contract. Tests shall include the following, and shall be performed when feasible, in the sequence listed:
1. Strength and Tightness Tests: Subject steam generators to the following strength and tightness tests.
 2. Hydrostatic Test: After installation and connection, subject each steam generator to an inspection and hydrostatic test to determine that the units and appurtenances have not been damaged in transit or handling. The hydrostatic test shall be in accordance with the ACME Code with the latest test pressure applied for a period required by the Owner. This test shall be in addition to the hydrostatic tests performed at the factory.
 3. Pneumatic Tests: Pneumatically test air casing exterior to the steam generator at the maximum working pressure. Use the soap bubble method to verify tightness.

4. **Safety Valves:** The high pressure limited switch shall be locked out or otherwise made inoperative, and the steam generator safety valves shall be lifted by steam. Determine the relieving capacity, popping pressure, blow-down, and reseating pressure by observation and measurement to be in accordance with the ASME Boiler and Pressure Vessel Code. The ASME standard symbol will be accepted only as indicating compliance with the design and material requirements of the code.
5. **Operation Test:** Continuously test the steam generators under varying load conditions to demonstrate proper operability of the programming control and safety interlocks. Conduct this test after the adjustment of the controls has been completed. The operational test shall continue for a period of at least 8 hours and shall include the following:

Sequencing: The steam generators shall start, operate, and stop in strict accordance with the specified operating sequence.

Preliminary Operational Test: Operate each steam generator and appurtenances prior to the final testing and ensure that necessary adjustments have been made. Provide testing equipment required to perform tests. During this testing period, provide operating instructions and training to persons tasked with operation of the steam generator.

6. **Auxiliary Equipment and Accessory Tests:** Observe and check blow-down valves, stop valves, try cocks, draft fans, pumps, electric motors, and other accessories and appurtenant equipment during the operational and capacity tests for leakage, malfunctions, defects, noncompliance with referenced standards, or overloading, as applicable.

3.3 MANUFACTURER'S SERVICES AND FIELD QUALITY CONTROL:

- A. **Warranty:** The entire unit and components shall have a minimum one year guarantee.
- B. **Start-up Service:** Entire unit shall have a start-up service and one year service period by factory-trained personnel.

END OF SECTION 23 57 10

SECTION 23 57 00 - HEAT EXCHANGERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide heat exchangers as shown, scheduled, indicated, and as specified.
- B. Types: The types of heat exchangers required for the project include, but are not limited to:
 - 1. Shell and tube heat exchangers.
 - 2. Flat plate heat exchangers.

1.3 QUALITY ASSURANCE:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
 - 1. Shell and Tube Heat Exchangers:
 - a. Bell & Gossett (preferred).
 - b. Patterson-Kelly.
 - c. Taco.
 - 2. Flat Plate Heat Exchangers:
 - a. Alfa-Laval.
 - b. Baltimore Aircoil.

1.4 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
 - 1. Cut sheets of the heat exchangers with construction, capacity, ratings, and accessories clearly shown.
 - 2. Include dimensioned drawings of heat exchangers.
 - 3. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver heat exchangers in factory-fabricated water-resistant wrapping.
- B. Handle heat exchangers carefully to avoid damage to material component, enclosure and finish.
- C. Store heat exchangers in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 SHELL AND TUBE HEAT EXCHANGERS:

- A. General: Provide shell-and-tube heat exchangers, complete with steel supporting saddles.
- B. Exchangers: Design water-to-water heat exchangers with number of passes and arranged as indicated on the Drawings. **[Steam to hot water converters shall be piped with steam in shell and a minimum of two water passes.]**
- C. Construction: Construct components of following materials:
 - 1.

Components	Material
Shell	Steel
Tube sheets	[Naval Brass] [Muntz Metal]
Tubes	[Stainless Steel] [18 BWG inhibited Copper Admiralty metal]

Heads (Removable) [5/8" OD,] [3/4" OD,]
[Cast iron] or [fabricated steel]

- D. Capacity: Provide units with capacities as scheduled on the Drawings. Pressure drops scheduled are maximum. Fouling factor of 0.0005 shall be included. **[Scale factor shall be 0.003.]** Water velocity shall not exceed 4 fps.
- E. **[Steam Connections: Provide steam, condensate, and vent connections to the exchanger shell. Steam inlet connection on shell shall be beyond the tube U-bends to prevent steam impingement on the tubes.]**
- F. ASME Symbol: A manufacturer's data report for pressure vessels, Form No. U-1 as required by the provisions of the ASME Code Rules, shall be furnished to the Engineer for the Owner. This form shall be signed by a qualified inspector holding a National Board commission certifying that construction conforms to the latest ASME Code for Pressure Vessels for 300 psig design pressure and system temperatures as indicated on the Drawings and as detailed on Form No. U-1. The ASME "U" symbol shall be stamped on the heat exchangers.
- G. Mounting Saddles:
- H. Painting: Heat exchangers and accessories shall be primed and finish-painted using the manufacturer's standard paint system.

2.2 FLAT PLATE HEAT EXCHANGERS:

- A. General: Provide flat plate heat exchangers, complete with frames and accessories.
- B. Exchanger Design: Design flat plate heat exchangers with number of plates and plate size required to provide the scheduled capacity. Pressure drops scheduled are maximum. Fouling factor of 0.0005 shall be included. Water velocity shall not exceed 4fps.
- C. Frame: Heat exchanger shall be provided with an epoxy coated steel frame with lifting lugs. Frame plate and bar design shall permit access to any plate in the plate pack without need to remove any other plates. All plate carrying and guide bar guiding system components shall be stainless steel. Carrying and guiding bars shall be designed for 15% future plate expansion capability. The fixed and movable covers shall be of sufficient thickness for the design pressure and code requirements without additional reinforcements of stiffeners.
- D. Connections: Connections 2" and smaller shall be stainless steel NPT type. Connections 2-1/2" and larger shall be studded port design to avoid leaks on the port area.
- E. Compression Bolts: The bolting system shall utilize only four compression bolts for opening and closing the unit. Compression bolts shall not require special tools and shall be equipped with lock washers at the movable cover to allow opening and closing of the unit from the fixed cover. Compression bolts shall be equipped with captive nuts at the fixed cover and threaded nuts at the movable cover. Welding of nuts to the compression bolts will not be acceptable. Compression bolts shall have rolled threads to reduce galling and double width hex nuts to adequately distribute bolt load. Bolts shall be factory lubricated and provided with protective plastic sleeves.
- F. Plates: Plates shall be pressed type 304 stainless steel with adequate heat transfer area to provide the scheduled capacity. Each individual plate shall be pressed from a homogeneous single metal sheet. Each transfer plate shall have herringbone corrugations to optimize heat transfer and provide support of adjacent plates. All plates and gaskets shall be permanently marked to identify quality and material. Plates shall incorporate a built-in aligning system. An aluminum plate pack shroud shall be provided.
- G. Gaskets: Gasket material shall be as scheduled or required for the proposed application. Gaskets shall have relieving grooves to prevent intermixing of fluids. All gaskets shall be one piece and shall fit around both the heat transfer areas and port holes. Non-glued gasketing systems are preferred. If adhesive is necessary, it shall be a two component heat cured epoxy glue which is compatible with the gasket materials and heat exchange fluids.
- H. Inspection and Testing: Plate heat exchangers shall be designed to withstand the full test pressure in one circuit with zero pressure in the alternate circuit. All exchangers shall be hydrostatically tested in accordance with ASME Section VIII, Division 1, Paragraph UG-99.

- I. Factory Insulation: Plate heat exchangers shall be provided with a factory installed insulation package. Insulation shall meet the flame spread and smoke developed requirements specified in Section 15200, "System Insulation".
- J. Drip Tray: Plate heat exchangers shall be provided with a factory installed drip tray.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install in accordance with manufacturer's instructions and ASME Code. Provide a pressure relief valve on closed loop side to prevent excessive buildup of heat or pressure. Relief valve shall be selected to coordinate with the piping system pressure rating.

3.2 TESTING:

- A. General: Test heat exchangers with connected piping systems.

3.3 INSULATION:

- A. Refer to Section 23 07 00, "System Insulation", for non-factory insulated heat exchanger component insulation requirements.

3.4 DRIP TRAY:

- A. Pipe condensate from heat exchanger drip tray to the nearest floor drain..

3.5 IDENTIFICATION:

- A. Refer to Section 23 03 00, "Basic Materials and Methods", for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 57 19

SECTION 23 62 13 - AIR-COOLED SPLIT SYSTEM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide split system air-conditioning unit work including, but not limited to, the furnishing and installation of:
 1. DX/Electric heat air handling units with related accessories and controls.
 2. Air-cooled DX condensing units with related accessories and controls.
 3. Manufacturer's controls that provide a complete and operational system independent of any other building controls.

1.3 QUALITY ASSURANCE:

- A. Manufacturer: Provide products of one of the following:
 1. Carrier Corporation,
 2. RECO,
 3. Trane Company,
 4. York.
 5. McQuay (part of Daikin Industries)
 6. Approved Equal.
- B. Certification: Provide manufacturer's certification of compliance with ARI Standard 210.

1.4 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. Refrigerant piping sizing calculations.
 5. Performance certifications and test results.
 6. Warranty information.
 7. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver DX/Electric heat air handling units, condensing units and accessories in factory-fabricated water-resistant wrapping.
- B. Handle DX/Electric heat air handling units, condensing units and accessories carefully to avoid damage to material components, enclosure and finish.
- C. Store DX/Electric heat air handling units, condensing units and accessories in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 DX/ELECTRIC HEAT AIR HANDLING UNITS:

- A. General: Provide the DX/Electric heat air handling units manufacturer's standard materials, components and accessories as indicated by product information, designed and constructed as recommended by the manufacturer and as required for a complete installation, except as otherwise

indicated. Units shall be rated and tested in accordance with ARI 210, 240 and 360 and shall be UL listed and labeled in accordance with UL 465/1995.

- B. Units: Air handling units shall be completely factory assembled in an insulated vertical housing, complete with DX cooling coils, condensate drain pan, fan, fan motor, electric heater (where scheduled), filters, controls and accessories. Units shall be factory wired for a single point electrical connection.
- C. Casings: Casings shall be constructed of heavy gauge zinc-coated, galvanized steel. Exterior surfaces shall be cleaned, phosphatized and coated with an epoxy resin primer and finished with an enamel finish. Casing shall be completely insulated with fire-retardant, permanent, odorless glass fiber material.
- D. Refrigerant Circuits: Units up to 7-1/2 tons shall have a single refrigerant circuit. Units 10 tons and larger shall have dual refrigerant circuits. Each refrigerant circuit shall be controlled by a factory installed thermal expansion valve.
- E. Evaporator Coils: Evaporator coils shall be configured aluminum fins mechanically bonded to seamless copper tubing. Coils shall be factory pressure and leak-tested to 375 psig air pressure. Coils shall be arranged for draw-thru airflow and shall be completely factory assembled, including expansion valves. Coils shall have condensate drain pans with external drain connections on each side of the unit. Dual circuited coils shall be circuited in an intertwined configuration.
- F. Cabinet Construction/Finish: Cabinet shall be constructed of galvanized steel with an acrylic high-heat baked-on enamel finish. The blower cabinet shall be internally insulated.
- G. Fan Section: Provide fan section (blower unit) as scheduled.
 - 1. Centrifugal Fans: Provide double width, double inlet, multiblade type fans with air foil, forward curved or backward inclined blades, as scheduled. All fans shall be statically and dynamically balanced and tested after being installed on properly sized shafts. Fan shafts must not pass through their first critical speed as unit comes up to rated rpm. Fan wheels and scrolls shall be constructed of galvanized steel, all aluminum or fabricated steel protected with two coats of rust-inhibiting paint. Wheels and scrolls of fans used for outside air service shall be coated with two coats of fire resistant epoxy paint.
 - 2. Sheaves: Permanent fan sheaves shall be nonadjustable with removable machined bushings, machined on all contact surfaces. Sheaves with over three grooves shall be dynamically balanced and so designated on each sheave. Fan sheaves with three grooves or less shall be statically balanced and if weights are required, they shall be welded to the sheave. Sheaves shall be manufactured by Browning, Eaton Yale and Towne, Dodge Manufacturing Company or Fort Worth Steel and Machinery Company.
 - a. Air Handling Units: Provide a nonadjustable type sheave selected for the rated fan rpm as determined. Provide variable sheaves as required to determine correct fan rpm as established by tenant requirements. Furnish additional fixed sheaves as required after correct speed has been determined. All unused fixed sheaves shall become the property of the Owner.
 - 3. Belts: Provide "V-groove" type suitable for the service intended with the capacities specified. Belts shall be closely matched and tagged for use prior to shipment. Recheck belts for proper match during operation and if necessary, replace with closely matched belt sets. Belts shall be Gates, Durkee-Atwood, Goodyear, Uniroyal or Browning.
 - a. General: Provide belt guards for all fan drives mounted outside the unit housing. The finish of the guard shall be similar to that of the unit housing. Brace and fasten guards to prevent objectionable vibration. Provide tachometer openings at least 2" in diameter for checking fan and motor speeds. Openings shall be centered on shafts to allow checking rpm.
 - 4. Shafts: Provide one piece design shafts, either solid or hollow tube with solid stub. Hollow tube with solid stub shafts shall be hot-formed, stress relieved, and manufactured by Pittsburgh Tubular Shafting, Inc. Fans and shafts shall not pass through their first critical speed as the unit comes up to rated rpm.

5. Shaft Bearings: Provide externally or internally mounted grease lubricated, self-aligning ball or roller bearings on each end of the shaft. Bearings shall have an average B-10 life as defined by AFBMA of 100,000 hours at design operating conditions. All bearings shall be the same size. Internally mounted bearings shall have grease lines extended so as to be readily accessible from the drive side of the unit. In addition, the bearing on the drive end of the shaft shall have grease line extended beyond the belt guard. All grease lines shall terminate in a zerk fitting. Bearings shall be by SKF, Sealmaster, Timken, or Fafnir.
 - H. Blower Motor/Drive: Blower motors shall be energy efficient 3 phase open drip-proof type. Refer to Section 15140 for additional requirements. Blower drive shall be a belt drive with adjustable pitch pulleys.
 - I. Blower Motor Starter: A factory wired, unit mounted NEMA type motor starter with 3 phase overloads and a control power transformer shall be provided.
 - J. Filter Rack/Filters: Provide units with a filter rack and 1" disposable filters.
 - K. Duct Connections: Unit shall be designed for outside air, return air and supply air connections as shown on the drawings.
 - L. Operating Controls: Furnish unit controls including system of automatic sequencing, safety and operating controls consisting of the following:
 1. High temperature cutoff.
 2. Differential air pressure switch to verify air flow.
 3. 115/24 volt control transformer.
 4. Programmable Space Thermostat for continuous fan operation during programmed occupied conditions.
 5. Two-stage heater capacity control (where scheduled).
 6. Firestat.
 7. Interlock unit controls with fan or air unit so that unit may not be energized with fan not in operation.
 - M. Performance/Ratings: Provide minimum performance as scheduled on drawings.
- 2.2 AIR-COOLED DX CONDENSING UNITS:
- A. General: Provide the DX condensing unit manufacturer's standard materials, components and accessories as indicated by product information, designed and constructed as recommended by the manufacturer and as required for a complete installation, except as otherwise indicated. Units shall be UL 1995 listed and rated in accordance with ARI Standard 210/240, 360 and 270.
 - B. Units: Provide air cooled condensing units of the size, type, capacity and arrangement as shown and scheduled on the Drawings. Condensing units shall be assembled on a heavy-gauge integral steel mounting/lifting base. Units shall be weatherproofed and include hermetic compressor(s), condensing coils, fans and motors, controls and holding charge of refrigerant. Units shall have a control box access panel and removable end panels which allow access to all major components and controls.
 - C. 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. Units shall have removable end panels for access to all major components and controls.
 - D. Refrigeration Circuits: Units up to 7-1/2 tons shall have single compressors and a single refrigerant circuit for use with a single circuit cooling coil. Units 10 tons and larger shall have two compressors and two independent refrigerant circuits for use with a dual circuit cooling coil. Each refrigeration circuit shall have an integral subcooling circuit and a refrigerant filter/dryer.
 - E. Compressors: Each compressor shall be a direct-drive hermetic type with centrifugal oil pump; two-point lubrication for each bearing and connecting rod; thermostatically controlled crankcase heater and well; high strength, ring-type suction and discharge valves; large gas passages and minimum clearance volumes; and internal spring isolation and muffling. External high and low cutout devices shall be provided. Evaporator defrost control provided in the indoor blower coil shall prevent

compressor slugging by temporarily interrupting compressor operation when low evaporator coil temperatures are encountered.

- F. 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.
- G. 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.
- H. 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.
- I. Controls: Unit controls shall include a fused 24-volt 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. A solid state anti-short-cycle timer shall be available for retrofit on all units to prevent rapid on-off compressor cycling in light load conditions. A time-delay relay shall be provided in all dual compressor units to prevent both compressors from coming on line simultaneously.
- J. Refrigerant/Oil Charge: Units shall be shipped from the factory with a sufficient charge of refrigerant and oil for the complete system when used with pre-charged refrigerant lines.
- K. Refrigerant Line Connections: Connections shall be either compression or sweat type. Brass liquid and suction line service valves, gauge/charging ports and a suction and discharge pressure gauge panel shall be provided.
- L. Warranty: The manufacturers one year parts and labor and five year extended (non pro-rated) compressor warranty shall be provided.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install DX/Electric heat air handling units and condensing units in accordance with manufacturer's instructions, the NEC, and applicable local codes and ordinances. Test installed systems 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. Condensing Unit Mounting: Mount units on reinforced concrete pads. Pads shall extend to a minimum of 3-1/2" above finished grade and shall be a minimum of 6" thick. Refer to Section 15100 for additional requirements.
- C. Air Handling Unit Mounting: Hang the unit from the structure with all thread and vibration isolators or set on a concrete pad.
- D. Leveling: Install units level to operate without noticeable vibration after installation.
- E. Vibration Isolators: Air handling units shall be installed with vibration isolators and separated from ductwork with flexible duct connections.
- F. Refrigerant Piping: Install, test, evacuate and charge refrigerant piping per the manufacturer's recommendations and as specified in Section 23 20 00.
- G. Drain Connections: Pipe condensate directly to a primed floor drain. Provide P-traps on air handling unit condensate drain connections with seal depths at least equal to the total static pressure of the unit as installed. P-traps shall be constructed of pipe and tees as detailed on the Drawings. Elbows shall not be used. All unused openings of tees shall be closed with removable plugs which shall serve as cleanouts.
- H. Filters: Install initial set of filters after ductwork has been blown out and prior to continuous operation of each air handling unit.

- I. Coil Pull Space: Air handling units shall be installed with adequate space to allow unit coils to be removed without demolition of building construction. Coil pull space and any required demolition of building construction shall be clearly indicated on As-built Drawings. The Contractor shall insure that all field-piping, valves, ductwork, and other obstructions are not in the way or can be easily removed with flanges to facilitate coil removal.
- 3.2 START-UP:
- A. Start-up, test, and adjust electric heaters in accordance with manufacturer's published start-up instructions. Adjust air diffusion louvers for proper air flow. Check and calibrate controls.
 - B. Controls: Unit controls, including, but not limited to overcurrent protection, magnetic evaporator fan and heater stage contactors, control power transformers, terminal strips, relays and a single point power entry shall be factory installed and wired in the unit such that the only field wiring required is a single power connection to the unit and control wiring to the thermostat and condensing units. Evaporator defrost control shall be provided to prevent compressor slugging by temporarily interrupting compressor operation when low evaporator coil temperatures are encountered.
- 3.3 TESTING AND BALANCING:
- A. Refer to Section 23 05 093 for air handling unit testing and balancing.
- 3.4 IDENTIFICATION:
- A. Refer to Section 23 03 00 for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 62 13

SECTION 23 64 16 - CENTRIFUGAL CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide water-cooled centrifugal water chillers and components as shown, scheduled, and indicated on the Drawings, including but not limited to:
 1. Chiller package.
 2. Charge of refrigerant and oil.
 3. Controls and control connections.
 4. Chilled water connections.
 5. Condenser water connections.
 6. Starters.
 7. Electrical power connections.

1.3 QUALITY ASSURANCE:

- A. Manufacturers: the design shown on the drawings is based upon products of the manufacturer scheduled. Equipment manufactured by Carrier, **[McQuay (part of Daikin Industries)]**, Trane or York will be acceptable if it meets the scheduled capacities and complies with these specifications. If equipment manufactured by a manufacturer other than that scheduled is utilized, then the Mechanical Contractor shall be responsible for coordinating with the General Contractor and all affected Subcontractors to insure proper provisions for installation of the furnished unit. This coordination shall include, but is not limited to, the following:
 1. Structural supports for units.
 2. Piping size and location.
 3. Electrical power requirement and wire, conduit and overcurrent protection sizes.
 4. The Mechanical Contractor shall be responsible for all costs incurred by the General Contractor, Subcontractors and Consultants to modify the building provisions to accept the furnished units.
- B. Standards: Products shall be designed, tested, rated, and installed in compliance with the following standards, as applicable.

1. ANSI/ASHRAE STANDARD 15-1978	Safety Code for Mechanical Refrigeration.
2. ANSI/ASHRAE 90A	Energy Conservation in New Building Design.
3. ANSI/ASME SEC VIII	Boiler and Pressure Vessel Code.
4. ANSI/ASME B31.S-1983 Piping.	ASME Code for Pressure Piping and Refrigeration
5. ANSI/UL 465	Central Cooling Air Conditioners.
6. UL 984	Safety Standards for Hermetic Motor Compressors.
7. ARI STANDARD 550-90	Centrifugal or Rotary Water Chilling Packages.
8. AFBMA 9	Load Ratings and Fatigue Life for Ball Bearings. Bearings must have life of not less than 200,000 hours.
- C. Ratings and Certifications: Products shall be rated and certified in accordance with the following:
 1. Conform to ARI Standard 550-90 code for rating and testing of centrifugal chillers.
 2. Conform to ANSI/UL 465 for construction of centrifugal chillers **[and provide UL label]**.

3. Conform to ANSI/ASME Section VIII Boiler and Pressure Vessel Code for construction and testing of centrifugal chillers.
4. Conform to ANSI/ASHRAE Standard 15-1978 code for construction and operation of centrifugal chillers.
5. Unit shall bear the ARI certification label for centrifugal water-cooled chillers as applicable.

D. [Factory Performance Testing: One chiller of each size specified for the project shall be factory performance tested under full load conditions in an ARI-certified test facility. The manufacturer shall supply a certified test report to confirm performance as specified. Proper ARI certification documents for the test loop shall be made available upon request from the manufacturer. The performance test shall be conducted in accordance with ARI Standard 550-90 procedures and tolerances.

1. **The performance test shall be run with clean tubes in accordance with ARI 550-90 to include the following:**
 - a. **A downward temperature adjustment per Section A7.3 shall be made to the design leaving evaporator water temperature to adjust from the design fouling to the clean tube condition.**
 - b. **An upward temperature adjustment per Section A7.3 shall be made to the design entering condenser water temperature to adjust from the design fouling to the clean tube condition.**
 - c. **Test temperature adjustments can be verified prior to test by the Vice President, Engineering, ARI. There shall be no exceptions to conducting the performance test with clean tubes and with temperature adjustments in Paragraph a. and Paragraph b. The manufacturer shall clean tubes, if necessary, prior to test to obtain a test fouling factor of 0.0000 hr. sq. ft. F/BTU.**
 - d. **Factory performance testing shall include integrated part load value (IPLV) testing. Test reports provided with O&M Manuals shall include raw data used in IPLV calculations.**
2. **The factory test instrumentation shall be per ARI Standard 550, and the calibration of all instrumentation shall be traceable to the National Institute of Standards and Technology (formerly NBS).**

[VERIFY IF A WITNESSED TEST IS REQUIRED]

3. **The Owner or his Representative shall be notified 14 days in advance to witness the factory performance test. If the Owner or his Representative desires to witness the performance test, all travel expenses will be the Owner's responsibility.**
4. **A certified test report of all data shall be submitted to the Engineer prior to shipping of chillers to the job site. The factory-certified test report shall be signed by an officer of the manufacturer's company. Preprinted certification will not be acceptable; certification shall be in the original.**
5. **Equipment will be accepted if the test procedures and results are in conformance with ARI Standard 550-90. If the equipment fails to perform within allowable tolerances, the manufacturer will be allowed to make necessary revisions to his equipment and retest as required. The manufacturer shall assume all expenses incurred by the Owner or his Representative to witness the retest. In the event that these revisions do not achieve submitted performance, the following penalties will be imposed:**
 - a. **Capacity Test: For each ton below the allowable capacity as set forth in ARI 550-90 of the design capacity, five hundred dollars (\$500.00) per ton will be deducted from the contract price.**
Allowable capacity = (1 - tolerance) x design capacity; tolerance per ARI 550-90, Section 5.4.

- b. **Power Consumption Test:** The power consumption penalty for all load points shall be based upon the tolerances set forth in ARI 550-90. The power consumption penalty (P.C.P.) will be calculated based upon the following formula:

$$\text{P.C.P.} = [\text{Measured kW} - (\text{Measured Tons} \times \text{Allowable kW/Ton}^*)] \times \$1000/\text{kW}$$

* Allowable KW/Ton = (1 + tolerance) x design kW/Ton; tolerance per ARI 550-88, Section 5.4.

- c. **Total Performance Penalty:** The total performance penalty will be the sum of Capacity Penalty and Power Consumption Penalty, times the number of typical chillers, regardless of whether all chillers are tested.

6. **Equipment manufacturer shall not invoice for the centrifugal chillers(s) until successful completion of the performance test or acceptance of penalty deduction from the contract.]**

- E. **Warranty:** Provide [two] [five] [_____] year warranty for chillers including coverage for [compressor] [compressor motor] [evaporator] [condenser] [complete chiller package] [gear box] [refrigerant metering system] as manufactured and delivered to site including [materials] [and labor] [only].
- F. **Maintenance Service:** Provide service and maintenance of chillers for period of [one] [two] [five] [_____] years from Date of Substantial Completion. Manufacturer shall have local stock of parts for centrifugal chillers proposed. Manufacturer shall have local service organization which shall have been established for at least 5 years.

1.4 SUBMITTALS:

- A. Shop drawing submittals shall include, but not be limited to, the following:
1. Drawings indicating components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and thermostatic valves required for complete system.
 2. Submit product data indicating rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.
 3. Written description of equipment functions and normal operating characteristics.
 4. Written operating instructions including check-out, adjustment, start-up, routine and normal operations, regulations and controls, and shutdown for emergency.
 5. Written instructions for installation and assembly, where required, including assembly drawings showing match-marking of field-assembled components.
 6. Chiller starter cut sheets with components, features, options, and wiring clearly indicated.
 7. Motor data as specified in Section 23 04 00, "Motors and Controllers".
 8. Wiring diagrams showing power and control wiring for chiller components, safety devices, and controls, clearly indicating both factory and field wiring.
 9. Written listing of limiting conditions of chiller including minimum permissible temperatures, minimum voltages, maximum and minimum permitted ambient conditions, maximum permitted chilled-water-entering temperature, recommended thermal shock, and change-over temperatures.
 10. Performance certifications and certified reports.
 11. Warranties and guarantees.
 12. Additional information as specified in Section 23 01 00.

1.5 HANDLING:

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- B. Protect units from physical damage. Leave factory shipping covers in place until installation.

PART 2 - PRODUCTS

2.1 CHILLER MATERIALS AND COMPONENTS:

- A. General: Provide chiller manufacturer's standard materials and components as indicated by his published product information, designed and constructed as recommended by the manufacturer and as required for a complete chiller installation as specified herein.
- B. Selection: Each chiller shall allow for a water side fouling factor of 0.00025 in the evaporator tubes and **[0.00075] [0.001]** in the condenser tubes. Evaporator and condenser water pressure drops shall not exceed those scheduled on the Drawings. The total kW power consumption of the units shall not exceed the scheduled kW on the Drawings **[and will be] [field-] [factory-]** verified in the chiller capacity test specified **[herein] [in Section 15675, "Chiller Field Capacity Testing"]**. Chillers shall be rated in accordance with the latest edition of ARI Standard 550-90 and shall conform to ASHRAE/ANSI 15-1978 Safety Codes.
- C. **[Refrigerants: Chillers shall be provided for use with [R-123 or R-134a].**
- D. Efficiency: Chiller full load efficiency shall be equal to or greater than that scheduled.
- E. Chillers: Shall consist of, but not be limited to, a complete system with compressor, motor, evaporator, condenser, lubrication system, purge system or pumpout unit, economizer or subcooler, capacity controller, instrument and control panel, unit mounted motor starter, factory-installed insulation and other items as specified herein or required.

2.2 COMPRESSORS AND MOTORS:

- A. Compressors: Shall be direct drive or gear driven, single or multistage centrifugal type. Capacity control shall be provided by fully modulating variable inlet guide vanes and shall allow capacity modulation from 100% of scheduled capacity to 15% of scheduled capacity at scheduled design conditions and with condenser water temperatures down to 65°F, **without hot gas bypass**. Guide vanes shall be controlled by an externally mounted electric operator in response to the refrigeration load on the evaporator. Impellers shall be high strength aluminum alloy and shall be directly connected to the motor shaft or gear driven. Compressor bearings shall be hydrodynamic sleeve type or tapered roller bearings. Sleeve bearings shall be either aluminum insert or steel backed babbit. Tapered roller bearings shall be stainless steel. The entire motor/compressor assembly shall be statically and dynamically balanced and tested at 25% overspeed. The motor/compressor assembly on direct driven units or motor/gearbox/compressor assembly on gear driven units shall be balanced to a maximum vibration amplitude of one mil as measured on the motor/compressor housing. All compressor casings shall be cast iron and shall be proof-tested at 1.5 times the maximum working pressure and leak-tested with refrigerant trace gas.
- B. Transmissions: If the compressor requires a speed-increasing transmission, it shall be hermetically sealed with the motor/compressor. The transmission shall be self-aligning with a parallel double helical gear arrangement having a minimum service factor of 1.2. If the thrust of the gears is counteracted by the design residual thrust of the impellers, single helix gear design will be acceptable. Each assembled compressor motor (transmission) shall be run-tested at the factory. At any bearing, neither the horizontal nor vertical vibration shall exceed 1.0 mil. Prior to installation, the manufacturer shall provide certified test results.
- C. Motors: Shall be hermetically sealed low-slip squirrel cage induction motors designed and guaranteed for continuous operation at nameplate rating. Motors shall be cooled with liquid or suction refrigerant circulated directly over the starter windings and between the rotor and starter. All motor windings shall be designed for operation in a refrigerant atmosphere. The motor shall be suitable for **[SCR controlled solid-state or] [Star-Delta reduced voltage]** starting at the voltage scheduled on the drawings. Motor winding temperature sensors, interlocked for unit shutdown, shall be provided for each phase.
- D. **[Open-drive Option: At the Contractor's option, open-drive equipment may be furnished in lieu of the specified hermetic equipment provided the following conditions are strictly met.]**
 - 1. **[Heat rejected to the Central Plant shall be removed by air handling unit(s) complete with chilled water cooling coils, valves, piping, controls and other required components provided at no additional cost to the Owner.]**
 - 2. **[Self-generated noise characteristics shall not exceed 78 dbA at full load, 81.5 dbA at 50% load and 81.5 dbA at 25% load.]**

3. **[Power consumption shall not exceed that of the specified hermetic machines over full operating range (15% to 100%), given constant 85°F to 95°F condenser water temperature.]**

- E. Lubrication: Force-feed lubrication shall be provided by a direct drive, positive displacement oil pump which shall provide positive lubrication to all bearings at all times. Power for the oil pump shall be supplied through the control power transformer/source. A lubrication oil filter with a differential pressure gauge shall be provided. A low voltage-density oil heater shall maintain oil temperature at a level to minimize its affinity for refrigerant. Power for the oil heater shall be supplied from a separate control power circuit and wired through the unit control panel. An integral or independent oil cooling system shall be provided. An interlock shall be provided to prevent motor starting unless oil pressure is established.

2.3 VESSELS AND ACCESSORIES:

- A. Evaporator and Condenser Vessels: Heat exchangers shall be of a shell and tube type designed in accordance with ANSI/ASHRAE 15-1978 Safety Code for Mechanical Refrigeration and ASME Code for Unfired Pressure Vessels and shall be appropriately stamped where required by ASME Code. The refrigerant side shall be proof tested 1.5 times the maximum design working pressure. The waterside working pressure shall be **[150] [300]** psi and shall be tested at 1.5 times design working pressure. Heat exchangers shall include water side taps for vent and drain connections as required. Waterside pressure drop shall not exceed scheduled values. Water side heads shall be removable to allow direct access to all tubes. Provide flanged connections with ANSI **[125] [150] [250]** pounds drilling for all heat exchanger supply and return piping.
- B. Evaporator: The evaporator shell shall be formed of carbon steel plate and shall incorporate a carbon rupture disc. The evaporator relief shall be piped through the building roof in conformance with applicable codes or as shown on the drawings. The chiller manufacturer shall be responsible for sizing the relief piping. End and intermediate tube sheets shall be carbon steel and shall be drilled for tube installation. Tube sheets shall be welded to the vessel shell and be fully self-supporting. Tubes shall be **[externally finned] [internally enhanced]** nominal 0.028" wall copper tubing mechanically expanded into the tube sheets. Tubes shall be individually cleanable and replaceable. Mesh screen eliminators shall be installed along the entire length of the evaporator to prevent liquid refrigerant carry over into the compressor. Liquid refrigerant entering the evaporator shall be distributed uniformly along its entire length without direct impingement of high velocity refrigerant on tubes. For standard water selections, minimum allowable refrigerant temperatures shall be 32°F at the design conditions scheduled with a minimum water side tube temperature of 33.5°F. The refrigerant side of the evaporator shall be vacuum and pressure leak tested with refrigerant trace gas. The evaporator shall be tested as specified hereinabove for Evaporator and Condenser Vessels. Provide a site glass at each evaporator, located such that the proper refrigerant charge is near the center of the glass with the unit off.
- C. Refrigerant Flow Control: Shall be by means of a positive metering device and the chiller shall be capable of starting and operating with entering condenser water at 65°F. Adjustable or float type refrigerant metering devices and thermal expansion valves shall be inspected and adjusted by the manufacturer annually for the first 5 years of operation to assure equivalent reliability to a fixed orifice system.
- D. Condenser: The condenser shell and tube sheets shall be formed of carbon steel plate. Condenser tubes shall be **[externally finned, internally smooth nominal 0.028"] [internally enhanced nominal 0.035"]** wall copper and shall be mechanically expanded into the tube sheets **[and shall be compatible with the Brush Cleaning System specified elsewhere in these specifications]**. Tubes shall be cleanable and replaceable. The condenser shall be tested as specified hereinabove for the Evaporator and for Evaporator and Condenser Vessels.
- E. Economizer: An economizer may be incorporated to help maintain the correct differential between condensing and evaporator pressures over the entire range of loading. All units utilizing subcooling must be provided with a thermometer well to monitor the amount of subcooling.
- F. Purge System: An automatic high efficiency purge system shall be provided on low pressure refrigerant (R-123, etc.) units to remove any noncondensables and water vapor present in the

refrigerant. At standard operating conditions and with a condensing refrigerant temperature of 80°F, the purge discharge shall be better than one pound of noncondensable per pound of refrigerant. The purge system shall include a purge compressor, controls, sight glass oil level indicator, electrically heated oil separator, sectionized drum permitting separation of noncondensable gases and water from the discharge of the compressor purge, a means of return refrigerant to the condenser and drawing off of noncondensables and solenoid valves to automatically isolate the purge system from the refrigerant circuit when the purge compressor is not in operation. A purge pressure gauge, a number of starts counter, and an hour meter shall be included on the purge system.

- G. **Pumpout Unit:** An automatic pumpout unit and storage vessel shall be factory installed on all high pressure refrigerant (R-22, R-114, R134A, R-500, R-501, etc.) units or the unit shall be capable of storing and isolating the entire refrigerant charge in the unit condenser vessel. Unit shall be factory-installed and piped and shall be furnished prewired with all necessary controls, transfer pump, condensing unit and tank constructed in accordance with ASME Code for unfired pressure vessels bearing the National Board stamp. Pumpout systems shall be supplied and warranted by the centrifugal machine manufacturer. Pumpouts shall comply with the following:
1. Pumpout tank(s) with ASME stamp capable of holding refrigerant charge when 80% full at 90°F.
 2. Separate charging connections for liquid and gas refrigerant.
 3. Piping and valves between pumpout and chiller to be supplied and installed by installing contractor. Contractor shall provide all piping, electrical equipment, and wiring required. Refrigerant piping shall be Type K hard-drawn copper with wrought copper fittings. Valves shall be packless type suitable for refrigerant use.
- H. **Recycle/Recovery Unit:** The manufacturer shall provide a portable Recycle/Recovery System. The system shall be modular allowing a single operator to transport, unload and install the system without requiring hoists, cranes, etc. the system shall include modular storage tanks, portable evacuation pump, heater, pump high pressure control, water cooled condenser, and pump starter. The system shall be compatible with **[R-123] [R-134a] []** and shall have a storage capacity of **[1000]** lbs. The system shall include 25 ft. of self sealing refrigerant hoses.
- I. **[Heat Recovery Bundle: Provide a separate heat recovery tube bundle integral to the unit condenser, where scheduled.]**

2.4 ACCESSORIES:

- A. **[Vibration Isolation: Vibration isolation shall be provided at all supports points. Refer to Section 23 05 48, "Vibration Isolation", for requirements.]**
- B. Refrigerant and Oil Charge: All chillers shall be provided with a full charge of refrigerant and oil. Refrigerant and oil charge shall be checked prior to startup. All or any part of the refrigerant or oil that may be lost during startup or the warranty period, shall be replaced by the chiller manufacturer at no additional cost to the Owner.
- C. **Thermometer Wells and Site Glasses:** Thermometer wells shall be provided to measure liquid refrigerant condensing and evaporating temperature and for all safety controls. Site glasses shall be provided for monitoring refrigerant and oil charge level, compressor rotation and the purge condenser drum.

[SELECT ONE OF THE FOLLOWING]

- D. **[Differential Pressure Sensors: Provide Orange Research, Inc. or approved equal differential pressure sensors with pressure switches and direct reading differential pressure gauges factory-installed to read across each heat exchanger. Differential pressure gauges shall be factory-mounted in the face of the chiller control panel and the pressure switches shall be factory-interlocked with the chiller controls to provide heat exchanger water flow verification. Sensors shall be similar to Series 1516 with 3-1/2" gauge readout, two reed switches and 316 stainless steel construction. Gauge range shall be adequate to monitor pressure drop from clean tubes to 0.0001 fouled tubes plus a 25% safety margin. Gauges shall be calibrated with water and shall be liquid filled to prevent pointer pulsation.]**

[OR]

- E. **[Flow Switches: Chillers shall have McDonnell-Miller No. FVS-7 or approved equal flow switches factory-installed and wired to provide chilled and condenser water flow verification.]**
- F. Insulation: All low temperature surfaces including, but not limited to, evaporator and water boxes, suction elbow, economizer and motor cooling piping, shall be factory-insulated with 3/4" closed-cell foam or an approved equal sheet insulation.
- G. Painting: All exposed surfaces and insulation shall be primed and painted using the manufacturer's standard paint system and colors.
- H. Refrigerant Leak Detection System:
 - 1. Follow minimum standards for Class One refrigeration systems as required by ASHRAE Standard 15-1989, with special attention to Sections 10.13-10/14 dealing with equipment room ventilation and air monitoring.
 - 2. Install an air monitor calibrated to detect concentrations of the refrigerant utilized in ppm.
 - 3. Install suitable local alarms and alarm contacts that activate well below the Threshold Limit Value (TLV) of the refrigerant and alert persons inside and outside of the equipment room that a leak condition exists.
 - 4. Provide N.C. contacts to monitor the leak detection system alarm condition by the Building Control and Automation System (BCAS). In the alarm mode, two (2) additional N.C. contacts shall be provided to start the mechanical room purge ventilation system.
 - 5. The manufacturer shall interface the leak detection system with the chilled controllers to shutdown the chillers in the alarm mode.

2.5 CONTROLS:

- A. General: The chiller(s) shall be controlled by a stand-alone Direct Digital Control (DDC) System. The controller shall provide chiller capacity control in response to the leaving chilled water temperature.
- B. Control Panel: The chiller control panel shall provide control of chiller operation and monitoring of chiller sensors, actuators, relays and switches.
- C. Safeties: The chiller control panel shall monitor such safeties as motor starting and running current, motor winding temperature (hermetic motors only), time between compressor/motor starts, low chilled water temperature, high condenser refrigerant pressure, low evaporator refrigerant pressure, high discharge pressure, evaporator and condenser water flows, low oil flow/pressure, and proper operation of unit controls and sensors.
- D. Gauges: The chiller control panel is to be provided with the following system pressure information:
 - 1. Evaporator refrigerant pressure.
 - 2. Condenser refrigerant pressure.
 - 3. Oil pressure.
 - 4. Purge drum pressure.
- E. Meters: The chiller control panel is to be provided with a starts counter and running time meter.
- F. Indicator/Displays: The front of the chiller control panel shall be capable of displaying the following:
 - 1. Entering and leaving evaporator water temperature.
 - 2. Entering and leaving condenser water temperature.
 - 3. Chilled water setpoint.
 - 4. Electrical current limit set point.
 - 5. Chiller operating mode.
 - 6. Chiller diagnostic codes and operating messages.
- G. Protection: The chiller control panel shall provide evaporator freeze protection and low limit control. This control shall be used to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and the actual value of the evaporator refrigerant temperature. A diagnostic code/message, reflecting the operating status, shall be automatically displayed at the front panel whenever this control is in effect.

- H. Control Interface Outputs: The chiller control panel shall provide a relay output to start the condenser water pump and/or enable the cooling tower temperature controls.
- I. Alarm Outputs: The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.
- J. Condenser Limit Control: The chiller control panel shall provide condenser limit control to include a pressure transducer and interconnecting piping and wiring. This control shall be used to avoid high condenser refrigerant pressure trip-outs during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and actual value of the condenser refrigerant pressure. A diagnostic code/message, reflecting the operating status, shall be automatically displayed at the front panel whenever this control mode is in effect.
- K. Low Temperature Startup: Include necessary controls to allow the water chilling unit to start with a condenser water temperature of 45°F (7.2°C) and operate continuously at 65°F (18.3°C) condenser water temperature. Single stage units or 2-stage units with inlet vanes in front of only one stage of compression, may utilize automatic hot gas bypass to allow operation at reduced load.
- L. **[Chilled Water Temperature Reset: The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature or ambient temperature.]**

[OR]

- M. **[Chilled Water Temperature Reset: The unit control panel shall provide leaving chilled water temperature reset based upon a pulse width modulated (PWM), [SCR controlled solid state or] 4-20ma or 0-10 VOLTS DIRECT CURRENT signal from a building automation system.]**

2.6 600 VOLT STARTERS:

- A. General: Each chiller motor shall be provided with a **[unit mounted] [free-standing] [SCR controlled solid state or] [star delta closed transition]** starter. Motor starter shall have NEMA 1A gasketed enclosure. **[Unit mounted starters shall be fully wired and tested such that only external power and control wiring connections are required in the field.]** Enclosure shall be constructed of 12 gauge steel minimum with the exception of doors which shall be code gauge steel minimum. **[Unit mounted enclosures shall have ventilating louvers or water cooled heat sinks.]** Each door or enclosure more than 48" high shall have three point vault type latches with padlockable handles and gasketing.
- B. Connections: Motor starters shall include incoming line provisions for the number and size copper cables shown on the Drawings. Incoming line lugs shall be copper **[mechanical] [compression]** type. Connection directly to the contactors is not permissible.
- C. Contactors: Star delta starter contactors shall be sized properly, per the NEMA requirements, to the chiller full load and locked rotor currents. Contactors shall have double break main contacts with weld resistant silver cadmium faces. Auxiliary interlocks that interface with the control panel shall have low resistance palladium silver contacts.
- D. Control Accessories: Each motor starter shall include a control power transformer with fused primary and secondary. Current transformers of the proper size, ratio and burden capacity shall be provided to provide a signal to the control panel and optional devices. Control relays shall be provided within the motor starter to interface with the control panel.
- E. Starter Wiring: Power wiring within the starter shall be Type MTW copper stranded 90°C. Power wire bends shall show no evidence of nicking or insulation degradation. Control wire shall be Type MTW copper stranded 90°C, 14 gauge minimum.
- F. Motor Protection: Starter shall include motor protection system incorporating electronic three phase overloads and current transformers. The electronic motor protection system shall monitor and protect against the following conditions:
 - 1. Three phase overload protection.
 - 2. Overload protection during start-up.
 - 3. Phase imbalance.

4. Phase loss.
 5. Phase reversal.
 6. Low voltage.
 7. Distribution fault protection consisting of 3-phase, current sensing devices that monitor the status of the current. Distribution faults of 1-1/2 electrical cycle durations shall be detected and the compressor motor shall be disconnected within six electrical cycles.
 8. A lockout transition safety circuit shall be provided to prevent damage from prolonged energization due to malfunction of the transition contractor. Malfunction shall cause the machine to be shutdown and the "starter circuit fault" indicator to be displayed. The overload system shall be coordination with the current control system to provide fail-safe circuitry. A single adjustment shall be used to set all three overloads.
 9. **[The motor protection system can, at the manufacturer's option, be furnished as part of the chiller control panel.]**
- G. Ambient Temperature: The starter shall be able to operate in temperatures up to 120°F.
- H. Additional Features: The following starter features shall be provided:

[EDIT TO SUIT PROJECT]

1. **[Circuit Breaker: Starter shall contain a circuit breaker with an interrupting capacity of [] RMS symmetrical amperes. Operating handle and trip indicator shall be located in the door. This handle shall be capable of being padlocked.]**

[OR]

2. **[Disconnect: A nonfused disconnect switch shall be provided.]**
3. Ammeters and Voltmeters: Three ammeters shall be provided, one per phase. Ammeters shall be calibrated so the inrush current can be indicated. Three voltmeters shall be provided, each reading a phase-to-phase voltage.
4. UL Approval: Starters shall be Underwriters' Laboratories, Inc. approved.
5. **[Capacitors: Power Factor Correction Capacitors shall be provided to correct to 93.5-95.5% at full load conditions (free standing starters only).]**

PART 3 - GENERAL

3.1 INSTALLATION:

- A. General: Install chillers, including components and controls required for chiller operation, in accordance with chiller manufacturer's instructions.
- B. Location: Locate chiller in general position indicated in relation to other work. Position chiller with sufficient clearance for normal service and maintenance, including clearance for cleaning and replacement of tubes and motor.
- C. Components: Install auxiliary piping, solenoid valves, shutoff valves, water strainers and controls for accessory systems, including but not limited to, oil cooler, compressor motor cooler, and purge and transfer system. Comply with manufacturer's instructions.
- D. Interlock: Interlock flow switches with chiller controls in accordance with the manufacturer's instructions, except as otherwise indicated.
- E. Supervision: The unit manufacturer shall supervise the installation and final checkout of the electrical interlock control wiring and review the location of the flow switches so that they perform the safety function without faulty operation or excessive vibration of the sensor.
- F. Finish: Paint damaged and abraded factory finish with touch-up paint matching factory finish.

3.2 RELATED WORK:

- A. General: Provide work related to and connected to chiller work and required for a complete chiller installation, including, but not limited to:
 1. Piping connections including provisions for disconnecting and servicing of chiller and cleaning/replacing of tubes.

2. Relief pipe from chiller relief opening to the outside, including a dirt trap and flexible connection. Size relief piping as recommended by the manufacturer.
 3. Tapping in condenser lines for acid cleaning.
 4. Isolation of chilled water and condenser water piping connections to chiller.
 5. Balancing valves in water piping for balancing system operations.
 6. Pipe strainers to protect chiller components and controls including pumps, automatic modulating valves, and pneumatic controls.
 7. Pipe support and bracing, adequately separated from chiller work in a manner preventing transfer of pipe stresses to chiller components.
 8. Flow switches or pressure differential switches, properly installed in a horizontal run of the chilled water piping and condenser water piping near the chiller.
 9. Connecting all miscellaneous piping including oil cooler and auxiliary water piping.
 10. Vibration and noise isolation as specified in Section 23 05 48.
 11. Ambient room conditions, including additional cooling, if required, for open drive motors.
 12. Wiring of flow switches or pressure differential switches for chiller interlock.
 13. Pressure gauges and thermometers as specified in Section 23 20 10, "HVAC Piping Valves and Accessories".
 14. Electrical wiring by Division 26 to compressor motor controller with interconnecting wiring to chiller control panel and unit motors, as required.
 15. Electrical wiring by Division 26 to oil pump/starter, refrigeration transfer compressor/starter and controls, if required.
 16. The unit control circuit shall be arranged so that on start up, the chilled water pump, condenser water pump and oil pump shall start first and the compressor motor shall start after operation conditions have been satisfied. On shutdown, the compressor motor shall stop first and the chilled water pump, condenser water pump and oil pump shall stop after a suitable time-delay period.
- B. Prestart-up: Complete the preparation and review the report on related work prior to chiller start up; do not start chiller until inadequacies have been corrected in a manner acceptable to the chiller Installer.

3.3 START-UP SERVICES:

- A. Manufacturer Supervision: A factory-trained technical service representative of the manufacturer shall supervise the field-assembly (if any), installation and startup of each chiller, for a minimum of five working days, plus one additional day for each chiller unit in excess of one unit. Prepare manufacturer's written report/log of the installation and startup, signed by the service representative and the Owner.
1. Representative shall supervise leak testing, evacuation, dehydration, vacuum pumping, charging, lubrication, including the filling of reservoirs and confirm that lubricant is of the quantity and type as instructed by the manufacturer.
 2. Representative shall instruct the Owner's operating personnel in the operation and service of the units for a period of one week, based on a 40 hour week, excluding nights, weekends, and travel time to and from the Project.
- B. Sustained Operation: Do not place chiller in sustained operation prior to initial balancing of the mechanical systems affected by chiller operation. Refer to requirements of Section 15020, "Operational Test-Adjust-Balance".
- C. Cooperation: Cooperate with other trades and installers of other work during the testing, adjusting, balancing, and start up of mechanical systems.

3.4 TESTING:

- A. General: Except as otherwise indicated, test chiller in accordance with ARI Standard 550-90.
- B. Pressure Test: Conduct a standing pressure test on the refrigerant circuit for a period of 12 hours using nitrogen without exceeding test pressure recommended by the manufacturer. Conduct a standing vacuum test on the vessel equal to 1 mm Hg absolute for a 24 hour period. Refrigerant shall

be charged, through filter dryers, to a recommended level. Machine shipped precharged need not comply with this requirement unless the factory precharge or holding charge is lost during shipment or prior to start up, in which case the Contractor shall test as indicated. Perform all tests and start up in such a manner as not to introduce moisture into the machine. Flush system as required to remove non condensables.

- C. **Oil Samples:** Obtain oil samples from each compressor at start up, label and send one sample in a clean, clear, suitable container with screw cap to the Engineer's office. **[Send one sample in a suitable container to Analysts Services, Inc., 12715 Royal Drive, Stafford, Texas.]** This sample will provide a base reference for all samples taken during the warranty period. At the end of the next two 30 day periods, samples as above shall be taken and distributed. If no recommendations are made by the Engineer or Analysts Services, Inc., samples shall then be taken at 60 day intervals and distributed as above. This testing program shall provide a minimum of eight samples of two each during the warranty period. Test shall include Karl Fisher Titration Test. If a problem is indicated at any time during this process, the Contractor shall take whatever steps necessary to ascertain the cause of any oil contamination. Any remedial measures shall be done at no expense to the Owner. The Contractor may at any time submit additional samples to the compressor manufacturer for analysis and a factory-recommended procedure to be followed. All remedial measures shall be reviewed by the Engineer before beginning any work.
- D. **[Annual Service: At the end of the one year warranty period, the chiller manufacturers service organization shall provide all labor, materials and equipment for an annual chiller service including, but not limited to: removing heat exchanger heads and inspecting/cleaning tubes, oil change/analysis, motor servicing and other manufacturer recommended service. This service shall be performed at no cost to the Owner.]**

END OF SECTION 23 64 16

SECTION 23 65 00 - PACKAGED STEEL COOLING TOWERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Scope: Extent of cooling tower work required by this Section is indicated on drawings and schedules, by requirements of this Section, and Section 23 01 00 "Mechanical General Provisions."
- B. Types: Types of cooling towers specified in this Section include the following:
 - 1. Induced-mechanical-draft.
 - a. Crossflow.
 - b. Counterflow.
 - 2. Provide the following models or approved equal.
 - a. Evapco AT-Line.
 - b. Marely NC Series.
 - c. BAC Series 3000.
- C. Arrangement: Consult the drawings for cooling tower arrangements. Tower dimensions and arrangements shall fit the space available.
- D. Related Sections: Refer to other sections of Division 23 for the following:
 - 1. Testing, adjusting, and balancing.
 - 2. Electronic variable speed drives.
 - 3. Vibration isolation.
 - 4. HVAC piping systems.
 - 5. HVAC Piping valves and accessories.
 - 6. Condensing water filter system.
 - 7. HVAC Sequence of Operation.
- E. Division 16: Refer to Division 26 sections for the following work:
 - 1. Power wiring and disconnects from the power source and VSD to connections on the tower.
- F. Other Divisions: Refer to other divisions of the specification for the following work:
 - 1. Structural steel supports.

1.3 QUALITY ASSURANCE

- A. Factory Fabricated Towers: Design, fabricate and test factory fabricated towers in conformance with CTI Tower Code, including:
 - 1. ATC-105 Standard Specifications for Thermal Testing of Wet/Dry Cooling Towers
 - 2. STD-111 Standard Specifications for Gear speed Reducers for Application on Industrial Water-Cooling Towers
 - 3. STD-131 Standard Specifications for Fiberglass-Reinforced Plastic Panels for Application on Industrial Water-Cooling Towers
 - 4. STD-201 Certification Standard for Water-Cooling Towers
- B. Wind Load: Design and certify towers for a wind load of 30 pounds per square foot.
- C. Seismic Design: Design to withstand seismic forces corresponding to Zone 1 designation of the Building Officials and Code Administrators International (BOCA) "Basic Building Code."

- D. Certifications: The cooling tower's performance shall be certified by the cooling Tower Institute (CTI) in accordance with CTI Certification Standard STD-201 or, a field acceptance test shall be conducted in accordance with CTI Acceptance Test Code ATC-105, by the CTI or other qualified independent third part testing agency. Submit certifications of tower conformance to CTI design and testing standards and American National Standard Institute (ANSI) A58.1, "Minimum Design Loads for Buildings and Other Structures."
- E. Codes: Provide tower components conforming to the following:
 - 1. Underwriters Laboratories, Inc. (UL) and National Electrical Manufacturers Association (NEMA): Provide motors, electrical wiring, conduit, lighting, and electrical devices listed and labelled to conform to UL and NEMA.
 - 2. Occupational Safety and Health Administration (OSHA): Construct stairways and ladders in conformance with OSHA requirements.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including rated capacities, pressure drop, fan performance data; weights (shipping, installed, and operating), installation and start-up instructions, and rating curves with selected points clearly indicated.
- B. Contractor's Certification: Submittals shall include a certification, signed by an officer representing the Contractor and stipulating that the submittal prepared by the manufacturer has been reviewed, and checked on an item by item basis.
 - 1. Equipment and products not in strict conformance with contract documents shall be separately submitted, clearly flagged and proposed under the change provision of the contract.
- C. Shop Drawings: Submit shop drawings indicating dimensions, weight loadings, required clearances and certification of conformance with referenced standards.
- D. Maintenance Data: Submit maintenance data and parts lists for each cooling tower, control, and accessory. Include this data, product data, shop drawings, and wiring diagrams.
- E. Controls: Submit shop drawing on:
 - 1. Make-up water level control and wiring diagrams.
 - 2. Bleed control.
- F. Additional information as required in Section 23 01 00.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Handle cooling towers and components carefully to prevent damage, breaking, denting, and scoring. Do not install damaged cooling towers or components, replace with new.
- B. Store cooling towers and components in a clean place. Protect from dirt, construction debris, and physical damage.
- C. Comply with manufacturer's rigging and installation instructions for unloading cooling towers and moving them to the final location.

PART 2 - PRODUCTS

2.1 COOLING TOWER GENERAL REQUIREMENTS

- A. Manufacturer: Provide cooling towers which are the product of a manufacturer regularly engaged in the production of cooling towers, who publishes descriptions and catalog capacities of the proposed equipment, who maintains facilities capable of testing towers in accordance with CTI testing requirements and can demonstrate that the proposed cooling tower product has been in satisfactory service for not less than three years prior to the date of Invitation For Bids of this Contract.
- B. Structural Supports: Modify design details of tower supports, structural framing, vibration isolators and concrete basins to suit cooling tower proposed.

1. Any modifications to the cooling tower supports, stub columns, additional structural steel of vibration isolators required to suit the particular tower shall be furnished without additional cost.
2. Vibration isolation modifications shall conform to the requirements of Section 23 05 48, "Vibration Isolation."
- C. Galvanizing: Where the term "galvanizing" is used in reference to cooling towers, it shall mean either hot-dip galvanizing or electro-deposited zinc coating at a rate not less than 2 ounces per square foot of surface, performed after the material has been fabricated.
 1. The use of zinc pigment paint in lieu of galvanizing will not be permitted.
- D. Steel Surfaces: Wire brush, clean and factory treat steel surfaces with a bonded coating, not less than 20 mils thick, guaranteed by the manufacturer to withstand the following tests.
 1. A spray coating 1/16-thick shall permit no corrosion on low carbon steel when exposed to a 20 percent salt spray at 95 degrees F. for 400 consecutive hours.
 2. The coating shall withstand a minimum 4,000 cycles in an accelerated weathering test without checking, alligating or perceptible loss of its protective quality.
 3. Provide surface coating with a fire hazard rating not to exceed 25 plus or minus 10, and the coating, during combustion, shall not drip, sag, or run. Rating shall be determined by American Society for Testing and Materials (ASTM) E 84 (NFPA 255), "Standard Test Method for Surface Burning Characteristics of Building Materials."
 4. Provide Type 316 stainless steel, where stainless steel is specified or is not noted.

2.2 INDUCED-DRAFT COOLING TOWERS

- A. General: Provide factory-assembled induced-draft counterflow or crossflow cooling towers of quantity, capacity, and sizes indicated on the drawings. Towers shall be designed for multiple or dual side air entry and with vertical air discharge.
- B. Cold Water Basin and Accessories: The entire cold water basin shall be constructed of heavy gauge Type 304 stainless steel. Each cell shall include a side outlet depressed or sloped sump, overflow, drain, stainless steel anti-vortexing hood and removable screen, and brass make-up valve with float assembly. Outlet connection shall be designed to mate with 125 lb. Pipe flange or grooved for mechanical coupling connection.
- C. Casing: The casing shall consist of stainless steel support structure and frame with a stainless steel mechanical support. Casing panels shall be constructed of heavy duty Fiberglass Reinforced Polyester (FRP). Fan deck shall be constructed of 304 stainless steel or FRP and designed as required to support weight of service personnel for maintaining tower. Casing shall be UV resistant to weathering.
- D. Louvers: The louvers shall be constructed of UV resistant FRP or PVC construction. Louvers shall be mounted in easily removable frames as required for access to the basin for maintenance. The louvers shall be designed to prevent splash out and block direct sunlight into the basin.
- E. Propeller Fans: Provide a fixed or adjustable pitch multi-blade heavy duty axial propeller fans statically balanced. Fans shall be constructed of aluminum alloy blades with cast aluminum hubs.
- F. Bearing and Drives: Provide the following bearings and drives installed by the manufacturer.
 1. Fan shaft bearings shall be heavy duty self-aligning ball bearings with moisture-proof seals. Bearings shall be designed for a minimum L-10 life of 75,000 hours.
 2. The fan drive shall be a multi-groove, solid back V-belt type with taper lock sheaves designed for 150% of the motor nameplate horsepower or geared reducer drive used in model provided.
 3. Belt material shall be neoprene reinforced with polyester cord and specifically designed for cooling tower service.
 4. Fan sheaves shall be aluminum alloy construction.
 5. Bearing lube lines shall be extended to the exterior of the unit for easy access.

- G. Motor: Provide a totally enclosed, air over (TEAO) type motor single-speed motor design for inverter duty. Motor shall be mounted on adjustable base for belt adjustment.
- H. Water Distribution System: Provide one of the following hot water distribution system:
 - 1. Gravity Type: Gravity type distribution system shall consist of 125 lb. Flange or grooved pipe inlet connection, pre-strainer assembly, stainless steel distribution basin, and replaceable nozzles installed in floor of hot water basin to ensure even distribution of water over the fill of gravity flow. Provide distribution basin covers constructed of high density polyethylene (HDPE) or Type 304 stainless steel.
 - 2. Spray Type: Spray type distribution system shall consist of steel pipe connection, schedule 40 PVC spray header and branches and removable ABS spray nozzles. The spray header and branches shall be easily removed for cleaning purposes.
- I. Fill: The cooling tower fill shall be PVC of crossfluted design. The fill shall be self-extinguishing for fire resistance with a flame spread rating of 15 or less per ASTM E84-81a. The fill shall be resistant to rot, decay, or biological attack.
- J. Eliminators: Provide drift eliminators constructed entirely of inert PVC. Maximum drift rate shall be less than 0.005% of the circulating water rate.
- K. Equalizer Connection: Each tower shall be supplied with a factory equalizer connection to balance the level of the basins for multiple cell or tower arrangement.
- L. Access and Safety:
 - 1. Access Doors: Provide hinged access door at both ends of the tower walls for access to eliminators and fan plenum section.
 - 2. Fan Guard: Provide a heavy gauge stainless steel wire fan guard for each fan cylinder.
 - 3. Ladders and Railings: Design in accordance with OSHA requirements. Construct of steel with safety cage as required. Ladders and railings shall be provided as required to access and maintain all cooling tower serviceable components, i.e., motor, fan drive, hot and cold water distribution systems, etc.
- M. Vibration Switch: Provide a factory-accessory, manual reset vibration switch with alarm contacts for each tower cell fan which shall de-energize fan motor if excessive vibration occurs due to fan imbalance. Alarm contacts shall be monitored by the BCAS. Vibration limit switch shall be in a cast iron waterproof NEMA enclosure.
- N. Bolting: Bolting connections shall be with stainless steel bolts, nuts, and washers. All joints shall be sealed watertight.
- O. Warranty: The mechanical equipment, with the exception of the motor itself, shall be warranted against failure caused by defects in materials and workmanship for a period of five (5) years from the date of tower shipment. The warranty shall cover the fans, speed reducers, couplings or belts, fan shaft and mechanical supports.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install cooling towers where indicated, in accordance with equipment manufacturer's written instructions and ensure that cooling towers comply with specification requirements and serve intended purposes.
- B. Access: Provide access and service space around and over cooling towers, but in no case less than that recommended by manufacturer.
- C. Placement: Install cooling towers on steel framing member provided under other section of the specifications. Level units to tolerance of 1/8-inch in 10 feet, in both directions.
- D. Piping Connections: Piping at cooling tower shall be supported externally to cooling tower so that no weight is born by cooling tower.
- E. Make-Up Water Piping: Provide flanged or union connections to cooling tower, with flexible pipe connections. Pitch lines so water will drain into sump. Connect to automatic fill valve with 3-valve bypass and backflow preventer.

- F. Drain Piping: Connect drain overflow and bleed lines to cooling tower full size of connection on cooling tower.
 - G. Electrical Wiring: Install electrical devices furnished by manufacturer.
- 3.2 ADJUSTING AND CLEANING
- A. Cleaning: Clean inside of cooling tower thoroughly before filling for start-up. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
 - B. Start-Up: Comply with manufacturer's instructions for filling and start-up of operation, but not less than the following:
 - 1. Verify lubrication of rotating parts; lubricate as needed.
 - 2. Verify fan rotation direction.
 - 3. Verify that motor amperage is in accordance with manufacturer's data.
 - 4. Balance condenser water flow to each tower and to each inlet for multiple inlet towers.
 - 5. Adjust water level control for proper operating level.
 - 6. Adjust bleed valve for indicated percentage of circulated water volume.
 - 7. Balance equalizer lines between multiple towers.
 - 8. Adjust temperature controls and verify operation.
- 3.3 CLOSEOUT PROCEDURES
- A. General: Provide services of manufacturer's technical representative for two 2-hour sessions to instruct personnel in operation and maintenance of cooling towers. One session at or around startup and one session into first cooling season.
 - 1. Schedule training providing at least 7 days notice.
- 3.4 SPARE PARTS
- A. General: Furnish the following spare parts:
 - 1. One spare set of matched fan belts for each belt driven fan.
 - 2. Three spare spray nozzles for each tower cell.
 - 3. One spare gasket for each gasketed access and inspection opening.

END OF SECTION 23 65 00

SECTION 23 72 23 – ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Provide and install a factory-assembled, self-contained air-to-air no heat) energy recovery unit (ERU) manufactured in the U.S.A. The ERU shall consist of, but not be limited to: insulated casing, supply fans, exhaust fans, motorized dampers, filters, **[air to air heat pipe], [energy recovery wheel], [air to air plate heat exchanger], [run-around coils], [cooling coils]**, electrical controls, electrical switched compartment lights completely factory wired, and accessories as specified.
- B. Unit shall be shipped as a single package unless the unit is too large to fit on a standard tractor-trailer.
- C. Perform all Work indicated by the Contract Documents with supplementary items required and necessary for proper unit installation.
- D. In general, all capacities of equipment and motor and starter characteristics are shown on the Drawings. Refer to the Drawings for such information. The capacities shown are minimum capacities. Variations in capacities of scheduled equipment supplied under this Contract will be permitted only with written direction of the Owner.
- E. Insofar as is possible, all items of the same type (i.e., wheel, coils, fans, etc.) shall be by the same manufacturer.
- F. Motor frame types and horsepower shown on the Drawings are the minimum. Provide motor horsepower to meet performance requirements.
- G. Design entering and leaving air temperature conditions, outside and exhaust air quantities and performance capacity requirements are indicated on the Drawings.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
- D. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- E. ASTM A653 – Hot Dipped Galvanized Steel Sheet.
- F. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- G. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

- H. AMCA 99 - Standards Handbook.
- I. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
- J. AMCA 300 - Test Code for Sound Rating Air Moving Devices.
- K. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.
- L. AMCA 500 - Test Methods for Louver, Dampers and Shutters.
- M. ARI 410 - Forced-Circulation Air Cooling and Air Heating Coils.
- N. ARI Guideline V – Calculating the Efficiency of Energy Recovery Ventilation and its Effect and Sizing of Building HVAC Systems.
- O. (ANSI) / ARI 1060 - Rating Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment.
- P. NREL/TP-550-26131 - Desiccant Dehumidification Wheel Test Guide.
- Q. NEMA MG1 - Motors and Generators.
- R. NFPA 70 - National Electrical Code.
- S. NFPA 90A Limits for Flame Spread and Smoke Ratings.
- T. UL 900 - Test Performance of Air Filter Units.
- U. (ANSI) ASHRAE 84 - Method of Testing Air-to-Air Heat Exchangers.
- V. ASTM C168 - Terminology Relating to Thermal Insulation Materials.

1.04 QUALITY ASSURANCE

- A. Energy recovery unit shall be provided by a manufacturing firm with minimum five (5) years of documented experience specializing in the engineering, design, fabrication and testing of energy recovery components.
- B. All calculations and efficiencies to meet the performance requirements of this Section are to be processed per the referenced applicable AMCA, ASHRAE 84 Standards, ARI, and NREL guidelines.
- C. No material may be used that, when tested by the ASTM E84-89 test method, is found to melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, thereby resulting in an artificially low flame spread rating.
- D. All materials shall have NFPA 90 rating of 25/50 or better.
- E. Inspect all ERU components and assemblies prior to shipment to the Project Site. A factory authorized representative shall perform a field inspection of the field assembled components and assemblies, and equipment installation, including all piping, electrical connections, and direct digital controls and instruments that are in the scope of manufacturing and testing of the ERU.

1.05 SUBMITTALS

- A. Product Data:

1. **Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gages and finishes of materials, electrical characteristics and connection requirements.**
 2. **Provide data for filter media, filter performance data, filter assembly and filter frames as tested and certified per ASHRAE and NFPA 90 flame spread and smoke rating standards.**
- B. Record Documents:
1. **Submit under provisions of Division 01.**
 2. **Provide fan curves with specified operating point clearly plotted, as tested and certified per AMCA standards. Ratings to include system effects. Bare fan ratings will not satisfy this requirement but shall be submitted for comparison purposes. All fan data shall be generated from specified testing. The fan shall compare favorably with the scheduled data listed in the Drawings. Where two fans are operated in parallel, provide Hagen's Line plots on fan curves, proving fans will not be operating in the unstable region.**
 3. **Submit sound power level data for both fan outlet and casing radiation at rated capacity, as tested and certified per AMCA standards. All fan data shall be generated from specified testing. The fan shall compare favorably with the scheduled data listed in the Drawings. The selected unit will not exceed the scheduled sound power data.**
 4. **Unit manufacturer shall submit full sound performance data to the Project sound consultant for evaluation. Unit shall be finally configured so as not to exceed sound levels as scheduled on Drawings.**
 5. **Equipment performance table comparing the performance of the energy recovery system against a conventional (per Specifications using two (2) six-row coils in series) outside air unit. The table should consider peak wet bulb design conditions to winter design condition of 20 degrees F, in 5 degree F wet bulb increments. This table shall also include the following data for every interval:**
 - a. Fresh air cfm, dry bulb and wet bulb (before and after the wheel).
 - b. Exhaust air cfm, dry bulb and wet bulb (before and after the wheel).
 - c. Purge section cfm.
 - d. Cross contamination cfm.
 - e. Pressure loss.
 - f. Fan power consumption (kW addition over standard unit).
 - g. Cooling tonnage reduction (sensible and latent).
 - h. Heating BTU added.
 - i. Operating RPM at each point (minimizing supply relative humidity and temperature.)
 6. **Provide efficiency ratings and performance data on all air-to-air energy recovery equipment being supplied with the ERU in accordance with ARI Guideline V, (ANSI) ARI Standard 1060, and in accordance with independent laboratory test per (ANSI) ASHRAE Standard 84.**

- a. If the ERU supplier does not have ARI certification for air-to-air energy recovery equipment, a letter signed by an engineering officer of the corporation must state that the ERU components meet or exceed the requirements of ARI Guideline V and ANSI Standard 1060, and a list documentation of equivalent performance test and the date of test must be enclosed with the letter.
- b. Provide performance data on finned tube coils as tested and certified per ARI Standards.

C. Operation and Maintenance Data:

1. **Submit Operating and Maintenance (O&M) Manuals with electrical requirements for power supply wiring including wiring and sequence logic diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring, parts list, with a description of operation and controls, and the required maintenance procedures.**
2. **Manufacturer shall prepare a spare parts list with cost per item for items that are necessary to keep the units operational.**

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect, and handle products to the Project Site under provisions of Division 01 and Division 20.
- B. Deliver materials to the Project Site in original factory packaging, labeled with manufacturer's identification including product thermal ratings and thickness.
- C. Store insulation in original wrapping and protect from weather and construction traffic. Protect insulation against dirt, water, chemical, and mechanical damage.
- D. All motors, enthalpy wheel segments, plate-to-plate exchangers, and coils are to be sealed in heavy plastic and stored in a protected area.

1.07 EXTRA MATERIALS

- A. Provide the following items with each shipment of the ERU to the Project Site:
 1. **Furnish two (2) sets of each filter type specified.**
 2. **Furnish two (2) sets of all types and size of belts for each driven component.**

1.08 WARRANTY

- A. Provide a two (2) year warranty on all parts except for filters. Provide a five (5) year warranty on the enthalpy and desiccant wheels. The warranty shall include the repair and replacement of any part, which fails during the specified time period. Include labor cost in all warranties.
- B. The warranty starts on Substantial Completion date.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. The following manufacturers are approved in principal subject to meeting this Specification:

1. **Annexair, Inc.**
 2. **Des Champs Technologies, Inc.**
 3. **Dessicant Rotors International, US, LLC.**
 4. **Semco, Inc.**
- B. Manufacturers and representatives are responsible for reviewing dimensional variances between the Contract Documents and the manufacturer's proposed and final dimensioned equipment Drawings. Since this is specialized equipment item, the manufacturer is also responsible for all coordination issues that may arise from design to Commissioning the ERU.

2.03 ENERGY RECOVERY COMPONENTS

A. Air-to-Air Heat Pipe Heat Exchanger:

1. **Comply with UL Standards.**
2. **Tube and fin material shall be compatible with the air streams.**
3. **Thermal recovery units shall be capable of operating at temperatures ranging from a minimum of -29 degrees C (-20 degrees F) to a maximum of 49 degrees C (120 degrees F). The heat transfer between air streams shall take place in a counter flow arrangement. The unit shall have no moving parts and shall be one-piece construction.**
4. **Tube core shall be either 18 mm (5/8 inch) or 25-mm (1 inch) OD seamless aluminum tubing permanently expanded into the fins to form a firm, rigid and complete metal pressure contact between the tube and fin collar of all operating conditions. Provide copper tubes and copper fins for corrosive air streams.**
5. **Secondary surfaces shall be of continuous plate type aluminum fins, 0.18 mm (0.007 inch) thick, and of corrugated design to produce maximum heat transfer efficiencies.**
6. **Basic capillary wick shall be an integral part of the inner wall of the tube and provide a completely wetted surface for maximum heat pipe capacity with minimum heat transfer resistance.**
7. **Refrigerants shall be approved by EPA.**
8. **Provide a vertical partition to isolate the exhaust and supply airstreams from each other, so that there will be no cross-contamination. Partition shall be a minimum of 1.9 mm (14 gage) galvanized steel. Provide stainless steel casing for corrosive air streams.**
9. **Casing shall be a minimum of 1.9 mm (14 gage) galvanized steel.**
10. **End covers shall be a minimum of 1.0 mm (20 gage) galvanized steel.**
11. **Provide a mechanism so that the unit can be tilted for summer-winter operation. Actuator used to tilt the unit shall be electric. Provide control panels and sensing bulbs as shown on the Drawings.**
12. **Provide flexible connectors for each side of the unit. The flexible connector shall be fabricated in a manner that will allow the unit to tilt without binding.**

B. Rotary Air-to-Air Heat Exchanger:

- 1. Comply with UL Standards.**
- 2. Wheel media for heat transfer such as aluminum, copper, stainless steel, or Monel, shall be compatible with the air streams.**
- 3. Exchanger Rotor or Wheel:**
 - a. Rotary enthalpy wheel that will provide the design dry and wet bulb temperatures as shown on the Drawings.
 - b. The wheel shall have a flame spread rating less than 25 and smoke developed rating less than 50 and shall be independently tested in accordance with ASTM standard E-84.
 - c. Rotor media shall be independently tested in accordance with ASHRAE 84. Rotor media shall allow laminar flow (but not radial) at a velocities to reduce leakage, bypassing and cross contamination by cross flow within wheel.
 - d. Size the transfer media to allow passage of 300 micron particles without fouling or clogging. When latent heat transfer is required, treat media with non-degrading desiccant that is bacteriostatic, non-corroding and non-toxic. No asbestos material will be allowed. Wheels constructed with paper substrate or polymer media materials are not acceptable.
 - e. Wheel shall not condense water directly or require a condensate drain for summer or winter operation. Performance rating shall be in accordance with this Section.
- 4. Provide casing seals on periphery of rotor as well as on duct divider and purge section if applicable for this ERU. The face rotor or wheel surface shall be ground and polished to form a smooth surface to achieve long seal life. The seals shall be adjustable, of extended life materials and effective in limiting air bypass leakage.**
- 5. Rotor or wheel shall be supported by roller bearings and belt driven by a fractional horsepower, totally enclosed; NEMA Standard motor through a close coupled positively lubricated speed reducer, or gear/chain speed reduction. Bearings should be serviceable and replaceable without having to remove the rotary wheel from the housing. Caster mounted rotor or wheels are not acceptable.**
 - a. Where constant speed wheel is indicated on the Drawings provide an AC motor.
 - b. Where variable speed wheel is indicated on the Drawings, exchanger wheel speed and leaving temperature control shall be achieved by means of a variable speed drive. Operation shall be 115/1/60 Volts and by a proportioning temperature controller that varies output voltage of a silicon-controlled rectifier (SCR) to a rectified power motor that will change speed in proportion to changes of voltage to its armature. Include an adjustable thermo switch for automatic changeover for summer-winter operation. Set point of adjustable proportioning temperature controller and thermo switch shall be indicated on visible scale. System shall be capable of speed reduction down to 5 percent of capacity while maintaining adequate torque at any point of operation to rotate wheel.
 - c. System should have an LED type wheel speed indicator, wheel rotation detection device with a local visual alarm on the unit, and an alarm contact to the building automation system (BAS) (flashing red-light) to alert building maintenance.
- 6. Purge Section:**
 - a. If purge section is required, maintain at minimum percentage of wheel area.

- b. Provide an automatic, factory built-in, field adjustable purge to limit exhaust air carry-over to less than 5.0 percent of rated volume.
 - c. Purge shall be effective when static pressure difference between supply and exhaust is 125 Pa (one-half, inch w.g.) or greater, and shall have provision for restriction or adjustment to limit purge air volume to not over 4.0 percent of rated air flow when a static pressure difference up to 2.5 kPa (10 inch w.g.) exists.
- 7. Accommodations shall be made to ease the cleaning or replacement of rotary wheels or rotary wheel sections.**
- 8. Unit shall be constructed of heavy gage steel to ensure rigidity and stability. Casing side panels shall be removable to ensure easy access to internal parts. Provide integral flanges for flanged duct connection and provide lifting holes or lugs.**
- C. Air-to-Air Plate Heat Exchanger:
- 1. Comply with UL Standards.**
 - 2. Access plate material shall be compatible with the air streams.**
 - 3. Plates: Corrugated 0.53 mm (0.021 inch) diamond embossed aluminum spacing as recommended by the manufacturer.**
 - 4. Bedding: Thermosetting reinforced resin. Provide plate seal-off and passage separation at top, bottom and center divider. The resins shall be self-extinguishing type in accordance with ASTM D635.**
 - 5. Casing and End Strips: Casing of 1.6 mm (16 gage) galvanized steel in accordance with NFPA. Provide stainless steel casing where corrosive air streams are present. End strips of the same material as exchanger plates. Ends of unit exchanger plates to be sealed with high temperature silicon sealant prior to installation of end strip for corrosive air streams provide welded end strips to avoid cross contaminations.**
 - 6. Provide integral flanges for flanged duct connections and provide lifting holes or lugs.**
 - 7. Furnish accessories where indicated on the Drawings.**
 - a. Face and bypass control dampers shall be constructed with galvanized steel blades and frame, with blade and blade jamb seals for low leakage performance. Dampers shall be provided by the manufacturer complete with electric actuators.
 - b. Provide factory installed controls to operate face and by-pass dampers during summer and winter operation.
 - c. Suspension mounting frame shall be the manufacturer's standard.
 - d. Roof mounting curb for units installed on roofs shall be the manufacturer's standard.
 - 8. [Provide a factory installed defrost system. The defrost system shall be capable of maintaining at least 85 percent of the non-frosted performance at -29 degrees C (-20 degrees F).]**
- D. Run-Around Energy Recovery System:
- 1. Provide a field fabricated system, as shown, containing coils, piping and [____] percent glycol, pumps, insulation and accessories.**

- 2. Tube and fin material shall be compatible with the exhaust air streams.**
 - a. [Note to Engineer: Pumps for run-around coils must be redundant if the loss of outside air relative humidity and temperature pretreatment could have a major affect on the health and well being of patients or cause an impact to laboratory animals.]
- 3. Provide automatic temperature controls and sequence of operations as shown on the Contract Documents.**

2.04 CASING AND BASE

A. Unit Casing:

- 1. Panels shall be double wall, reinforced construction with sufficient internal bracing to prevent excessive deflection of the panels.**
- 2. Exterior walls minimum 16-gage G-90 galvanized and interior walls minimum 20-gage G-90 galvanized steel. The interior casing wall of the cooling coil section shall be 20-gage Type 304 stainless steel sheet material.**
- 3. Internal insulation shall be minimum R-value of 12 and fire, mold, and fungus proof.**
- 4. All sheet metal joints throughout the air-handling unit and between panelized sections shall be sealed with closed cell, soft rubber gaskets, fabricated from neoprene, EPDM, or other approved material.**
- 5. Provide airtight enclosure where the air unit casing encloses building columns. Leakage rate shall not exceed that allowed for the unit casing.**
- 6. Maximum deflection at any point on the unit casing shall be limited to 1/200th of the overall panel width or height.**
- 7. Provide a thermal break protection between exterior panel and inner panel construction joints to eliminate all through-metal portions of the unit so that there will be no external condensation.**
- 8. Panel surfaces shall be non-condensing per ASTM D 4230, Measuring Humidity with Cooled Surface Condensation.**
- 9. All surfaces of the ERU casing and base exposed to an outside environment shall have a powder coat finish.**

B. Drain Pans:

- 1. Provide IAQ style drain pan under the entire cooling coil section, per compliance with ASHRAE Standard 62.**
- 2. Drain pan shall extend minimum 24 inches downstream of the cooling coil section.**
- 3. Construct drain pan of minimum 14-gage Type 304 stainless steel.**
- 4. Insulate the under side of the entire drain pan with two (2) part sprayed on polyurethane closed cell foam with a minimum of R-8 insulation value. Insulation shall be water impervious rigid type, after curing, and shall occupy all voids and areas between drain pan and outer wall to prevent the occurrence of trapped water, condensation, and microbial growth. Install and seal insulation as appropriate for the equipment construction.**

5. **Slope drain pan in all planes to the drain connection to prevent accumulation of standing water. On units over ten (10) feet in width, slope pan to drain on both sides of the unit.**
6. **Condensate from drain pans shall be piped as indicated on the Drawings. The pipe size shall be 1-inch minimum diameter, insulated as specified for chilled water piping. A trap as required to prevent the escape or entry of air through the drain piping shall be provided as indicated on the Drawings.**
7. **Provide an insulated intermediate drain pan for all coils above another coil, factory piped to main drain pan. Drain pans shall be sloped and constructed of 16 gage Type 304 stainless steel to match the main drain pan and shall extend 6 inches from the coil face.**

C. **Base and Floor:**

1. **Construct each unit section on a structural base that supports all major components (i.e., fans, coils, etc.) and shall be supported with structural steel members). Base and structural members shall be minimum 12 gage G120 galvanized steel.**
2. **Complete perimeter channel base shall be minimum 6 inch galvanized steel. Base rail height shall be sufficient to meet the lowest coil drain connection to allow for proper condensate drain trap depth in accordance with the Drawings.**
3. **Fabricate base of electrically welded structural steel members. Use welding procedures and welders certified for structural steel welding according to AWS D1.1 Structural Welding Code - Steel, and AWS D1.3 Structural Welding Code - Sheet Steel.**
4. **Unit floor panels shall be 16-gage, galvanized steel over expanded foam insulation with a minimum R-value of 8. Hex head zinc coated fasteners shall be used to attach the flooring panels and shall be attached to welded structural frame members. Dow Corning HVAC/R silicon sealant material shall be used to seal the mating surfaces between floor panels and frame members.**
5. **20-gage galvanized sheetmetal shall enclose the insulation on the bottom of the unit.**
6. **All points of contact between the floor, vapor barrier, and structure shall be thermally isolated and sealed with closed-cell soft rubber or EPDM.**

D. **Access Doors:**

1. **Access doors shall be double wall, insulated the same as wall panels, and the opening framed with thermal break construction.**
2. **Provide access doors to allow access to both sides (upstream and downstream) of the pre-filter racks, energy recovery components, and cooling coils. Access doors of the fan sections shall be located on the motor side.**
3. **Door size shall be minimum 18 inches wide and full panel height up to 72-inch tall units. For units above 72 inches tall, provide 72-inch high doors. For panels over 36 inches wide, provide 36-inch wide doors.**
4. **Access door construction shall equal or exceed the quality of air handler casing materials as specified herein.**

5. **Each door shall have a minimum 8-inch by 6-inch double glazed view window, capable of withstanding the total developed pressure of the unit.**
 6. **Doors shall be hinged using either heavy-duty adjustable stainless steel butt hinges or a continuous adjustable stainless steel piano hinge, extending along the entire edge of the door, except for a maximum of two inches at each end. If butt hinges are used, provide two (2) per door for up to 36-inch high doors and three (3) per door for longer doors. Provide minimum of two (2) latches on doors longer than 18 inches and three (3) latches on doors over 36 inches long. Latches shall be Ventlok 310, heavy-duty latch.**
 7. **All access doors shall open against air pressure, unless approved by the Owner in writing.**
 8. **All exterior surfaces of the access doors exposed to an outside environment shall be zinc coated galvanized panels with a protective finish (ASTM A653/A) and shall have a baked enamel finish.**
 9. **Intake hoods and exhaust hoods, complete with bird screening over the openings, shall be standard on all outdoor units.**
- E. Rigging Performance Requirements:
1. **Provide lifting lugs suitable for rigging without requiring additional support frames or rails.**
 2. **Provide units that may be lifted without permanent deformation to the housing, base or internal components.**
 3. **Indicate physical balance point on unit bases.**

2.05 FANS

- A. Provide fan sections with [double-width double-inlet (DWDI) centrifugal type], [forward curved (FC)], [airfoil (AF)], [backward inclined (BI)], or [single-width single-inlet (SWSI) plug (PF)] fans, minimum class II, constructed of galvanized steel, as scheduled.
1. **Higher RPM AF and BI fan casings shall come equipped with additional heavy-duty rectangular angle framework for increased strength and stability.**
 2. **Fan and unit performance shall be rated and certified in accordance with ARI 430, AMCA300 and ARI 260 as specified elsewhere herein.**
 3. **Fan wheels shall be keyed to the fan shaft and shall be statically and dynamically balanced at the factory as a complete fan assembly regardless of duty.**
 4. **Dynamic fan balancing shall be conducted from 16Hz to 66Hz to identify and eliminate critical speeds and to ensure stable operation through the entire operating range of the fan and drive assembly. Forward factory balancing test report upon request of Engineer.**
- B. Mount motor drive and fan on integral framework, internally isolated from the casing with factory installed 1-inch deflection spring vibration isolators on units with 8 square feet of coil area or less, and 2-inch deflection on units with coils greater than 8 square feet in area. The fan, drive, and base assembly shall be factory point load tested and balanced with corner isolators selected accordingly for increased stability and to minimize fan assembly noise and vibration and extend bearing life.

- C. Provide internal flexible connection on discharge of fan to isolate fan from casing. Additionally, provide spring loaded fan-shroud-to-casing thrust restraints for all airfoil and backward inclined fans, and on all units with coil face areas greater than 30 square feet.
- D. Fan motors shall be premium high efficiency and VFD compatible. Refer to Section 23 05 13, Variable Frequency Drives.

2.06 BEARINGS AND DRIVES

- A. Bearings: Provide self-aligning grease lubricated, pillow-block ball bearings. Bearings shall be lubricated at the factory and equipped with means for lubrication on the outside of the bearing housing. Bearings shall be designed for an average life (L10) of at least 200,000 hours at the maximum horsepower and operating speed for the classification. Opposite drive side fan bearings shall be sized appropriately to prevent premature wear and bearing skating from uneven loads on bearings to extend bearing life.
- B. Motors shall be in compliance with Section 20 05 13 and compatible for use with variable frequency drives.
- C. Shafts: Solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil. Shafts shall not pass through first critical speed as unit comes up to rated RPM and shall be balanced as part of the fan assembly as described above.
- D. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, bored to fit shafts and keyed. Variable and adjustable pitch sheaves for motors 15 horsepower and under. Select variable and adjustable pitch sheaves so that required RPM is obtained with sheaves set at mid-position. Provide fixed pitch sheaves for motors equipped with variable speed drives. Provide belts and drive rated for minimum one and one-half times nameplate rating of motor.
- E. Direct Drive: Units with scheduled plug fans shall be direct drive.

2.07 WATER COILS

- A. Provide counterflow chilled water and hot water coils as scheduled. Provide vertical or horizontal coil connection entry to unit casing per the Drawings to maximize maintenance accessibility and minimize coil piping and valve interference. Cooling and heating coils used for outside air pretreatment shall have copper fins in lieu of aluminum fin configuration.
- B. Slide the individual coils into the coil casing through a removable end panel with blank off sheets and sealing collars at connection penetrations. The coil support steel and coil casing is to be made with Type 304 stainless steel for cooling coils and hot dipped galvanized carbon steel for heating coils.
- C. Rate coils in accordance with ARI certified data. Select coil to provide capacity in accordance with water flow and temperatures scheduled on Drawings with maximum water pressure drop through coil as scheduled and a maximum velocity in tubes of 8 feet per second. Provide coil with maximum allowable face velocity as indicated on Drawings.
- D. Provide 1/2-inch or 5/8-inch outside diameter copper tube coils, with a maximum six (6) row depth and a maximum 8 fins per inch spacing supplied with copper headers. Steel pipe water connections shall be welded to copper headers with silica-bronze weld to prevent dielectric corrosion of dissimilar metals, or coil connections shall be provided with isolating devices such as (dielectrically insulated flanges) to extend the life of the coils. If additional rows are required pipe coils in series and provide access section between coils.

- E. Provide coils with plate fin wall thickness of 0.006-inch and tubes of minimum wall thickness of 0.035-inch for 5/8-inch coils and 0.020 for 1/2-inch coils. Connect tubes to header that provides equal flow to all tubes and provide single point connections for supply and return piping per coil. Factory test all coils to 325 psig and forward coil test reports to the Engineer with submittal documentation.

2.08 FILTER SECTIONS

- A. General: Air shall not be allowed to bypass around filters. Provision shall be made to positively lock filters in place to prevent shifting. Provide applicable filter and final filter sections as scheduled on the Drawings. Note: Some units may have multiple filter sections and multiple filter types.
- B. Angle Filters: Low-velocity angular filter frames with integral, side-access, galvanized steel or extruded aluminum filter frames suitable for 2-inch media. Combine with mixing box where scheduled on Drawings.
- C. Flat Filters: Flat (perpendicular to airflow direction) filter frames with integral, side-access, galvanized steel or extruded aluminum filter frames suitable for 2-inch or 4-inch media (as scheduled).
- D. Open Return Filters: Flat (perpendicular to airflow direction) filter frames with integral, front-access, galvanized steel or extruded aluminum filter frames suitable for 2-inch or 4-inch media (as scheduled).
- E. Cartridge (Rigid) Filters: Flat (perpendicular to airflow direction) filter frames with integral, front or side-access, galvanized steel or extruded aluminum filter frames, with neoprene gasket seal material on the leaving air side of the filter, suitable for a 2-inch pre-filter media and a 12-inch rigid filter media.
- F. HEPA Filters: Flat (perpendicular to airflow direction) filter frames with integral, front-load access, galvanized steel or extruded aluminum filter frames, with leak-free neoprene gasket seal material on the leaving air side of the filter, suitable for a 24-inch high efficiency HEPA filter media.
- G. Filter Gauges: Magnahelic differential pressure gauges shall be installed and mounted on drive side of unit to measure the pressure drop across the filter sections as indicated on the Drawings and/or control schematics.
- H. Refer to Section 23 40 00 for filter media.

2.09 MARINE LIGHTS AND GFI RECEPTACLES

- A. Marine lights shall be provided in access compartments as shown on the Drawings. Access lights shall be wired to a single watertight switch located on the exterior side of unit. A marine GFI receptacle shall be mounted next to the light switch. A separate 120 Volt power connection shall be used for the GFI receptacle. All electrical penetrations through the wall of the ERU shall be sealed by the manufacturer.

1. [Note to Engineer: Identify access light locations and receptacles on the Drawings.]

- B. Provide electrical fused-disconnects with units. Units that are exposed to an outdoor environment shall have weatherproof fused-disconnects.

2.10 CONTROLS

- A. Unit shall be provided with manufacturer's control panel and instruments.

- B. Instrumentation and DDC controls furnished with the ERU shall be compatible with the Building Automation System (BAS) using a BACnet operating system.
- C. The DDC controls at a minimum shall consist of a standalone controller, I/O board(s), and instrumentation to provide remote and local indication of entering and leaving relative humidity, and dry and wet bulb temperatures on ventilation air inlet and exhaust air outlet sides of the energy exchange components within the ERU. All filter differential pressures and fan static pressures are to be indicated and monitored by the BAS. The stand alone controller shall also include functions for purging, speed detection, motor protection, and an alarm.
- D. **[If scheduled on the Drawings, the system should modulate rotor speed between economizer operation down to 0 RPM and maximum heat recovery to 18 RPM when outside air temperature is at peak. Economizer control to reduce rotor speed and prevent discharge air from rising above setpoint.]**
- E. Seal all instrumentation wiring or controls wiring penetrations through the casing of the ERU.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Follow the equipment manufacturer's instructions for handling and installation, and setting up of ductwork for makeup and exhaust air steamers for maximum efficiency.
- D. Rotary air-to-air exchanger: Adjust seals and adjust purge settings (if used) as recommended by the manufacturer. Verify correct installation of controls.
- E. Seal ductwork connections per the applicable related specification to avoid air leakage.
- F. Provide adequate spacing and access for cleaning and maintenance of heat recovery coils as well as filters.
- G. Secure the energy recovery unit to withstand a wind velocity of [____] miles per hour, if unit is mounted on a roof or outdoors.
- H. Arrange all water piping to coils so the water circuits are serviceable, without having to dismantle excessive lengths of pipe to remove the coils.
- I. Provide the drain valves and vent cocks for each of the coils.
- J. Provide strainers ahead of recirculation pumps and control valves.
- K. Provide certified wiring schematics to the electrical division for the equipment controls.
- L. Provide all necessary control wiring as recommended by the manufacturer or the ERU.
- M. Provide the correct condensate traps to compensate for blow or draw through pressure characteristics.

3.02 TESTING

- A. Prior to an integrated test and Start-up of this unit, a factory-authorized field service representative is to perform the following:

- 1. Verify that the unit has specified filtration installed.**
- 2. A full inspection of the assembled unit to confirm the correct rotation of motors.**
- 3. To make seal and / or damper adjustments, test and adjust controls and interlocks.**
- 4. Set and verify initial setpoints on controls and instruments.**
- 5. Perform required final performance leakage test measurements and record for verification by to the Engineer prior to final approval and acceptance of the ERU.**

3.03 TRAINING

- A. Provide services of manufacturer's technical representative for four hours to train and instruct Owner about the operation and maintenance requirements of ERU and its energy recovery components.

END OF SECTION 23 72 23

SECTION 23 73 24 – CUSTOM FAN WALL AIR HANDLING UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install factory assembled, custom-built air handling units, including factory installed fans, dampers, filters, coils, motors and any specialty equipment as indicated by the Contract Documents with supplementary items necessary for proper installation.
- B. This Specification applies to all air handling equipment scheduled with over 20,000 cfm capacity and for special applications as scheduled on the Drawings.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
 - 3. AMCA 99 - Standards Handbook.
 - 4. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
 - 5. AMCA 300 - Test Code for Sound Rating Air Moving Devices.
 - 6. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.
 - 7. AMCA 500 - Test Methods for Louver, Dampers, and Shutters.
 - 8. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
 - 9. ARI 610 - Central System Humidifiers.
 - 10. NEMA MG1 - Motors and Generators.
 - 11. NFPA 70 - National Electrical Code.
 - 12. NFPA 90A - Flame Spread and Smoke Ratings.
 - 13. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

14. UL 900 - Test Performance of Air Filter Units.

15. ANSI/ASHRAE/IESNA Standard 90.1 – Energy Standard for Buildings Except Low Rise Residential Buildings.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this Section with minimum three (3) years documented experience, who issues complete catalog data on total product.

1.05 SUBMITTALS

A. Product Data Record Documents:

1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gages and finishes of materials, electrical characteristics and connection requirements. Refer to detailed list of submittal data in this Section.
2. Provide data of filter media, filter performance data, filter assembly and filter frames as tested and certified per ASHRAE and NFPA 90 flame spread and smoke rating standards.
3. Provide fan curves with specified operating point clearly plotted, as tested and certified per AMCA standards. Ratings to include system effects. Bare fan ratings will not satisfy this requirement but shall be submitted for comparison purposes. All fan data shall be generated from specified testing. The fan shall compare favorably with the scheduled data listed in the Drawings. Where two fans are operated in parallel, provide Hagen's Line plots on fan curves to prove that fans will not be operating in the unstable region.
4. Submit sound power level data for both fan outlet and casing radiation at rated capacity, as tested and certified per AMCA standards. All fan data shall be generated from specified testing. The fan shall compare favorably with the scheduled data listed in the construction drawings. The selected unit will not exceed the scheduled sound power data.
5. Unit manufacturer shall submit full sound performance data to the Project sound consultant for evaluation. Unit shall be finally configured so as not to exceed sound levels as scheduled on Contract Documents.
6. Provide data on all coils as tested and certified per ARI standards.
7. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
8. All materials shall have NFPA 90 rating of 25/50 or better.
9. Base Rail Height Calculations: Provide calculations for required base rail heights to allow for proper condensate trapping per condensate drain details.

B. Operation and Maintenance Data:

1. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists and wiring diagrams.
2. Provide Operating and Maintenance (O&M) Manuals for air handling units. In addition to a full set of manuals with closeout documentation, each unit shall ship with its own manual permanently mounted inside the unit casing fan section in a watertight enclosure.

3. Permanently mount condensate trapping calculation instructions within the unit O&M Manual that illustrates the unit casing at the condensate drain connection.
4. Manufacturer's Instructions: Provide Start-up information and maintenance required prior to Start-up.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to the Project Site under provisions of Division 01 and Division 20.
- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- D. Protect openings in casing and seal them with plastic wrap to keep dirt and debris, also protect coils from entry of dirt and debris with pipe caps or plugs.

1.07 EXTRA MATERIALS

- A. Provide [one] ~~[two]~~ additional sets of specified filters for each unit, packaged for storage after each unit has been tested and operated for final acceptance by Owner. Tag products to identify associated unit.

1.08 SCHEDULES ON DRAWINGS

- A. In general, all capacities of equipment and motor and starter characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the Owner.
- B. Insofar as is possible, all items of the same type (i.e., coils, fans, etc.) shall be by the same manufacturer.
- C. Where installation instructions are not included in the Contract Documents, the manufacturer's instructions shall be followed.
- D. Motor and wheel diameters shown on the AHU schedules are the minimum. If a larger wheel diameter or horsepower is required, it shall be so quoted and noted on evaluation forms in this section.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Configuration: Fabricate with fan and coil sections plus accessories as indicated on the Drawings, including but not limited to:
 1. Preheat coil.
 2. Heating coil.
 3. Mixing box section.

4. Applicable filter and final filter sections.
 5. Cooling coil section.
 6. Humidifier section.
 7. Motors and variable speed drives.
 8. Access doors.
 9. Dampers.
 10. Silencer sections.
- C. Base performance on sea level conditions, unless otherwise scheduled.
- D. Fabrication: Conform to AMCA 99 in the absence of direction in this Specification.
- E. Performance: Refer to schedule in Drawings.
- F. Provide a unit with a total footprint size (length and width) that will not exceed the one shown on the Drawings, including the height of individual unit components.
- G. Dual duct units shall have separate hot deck and cold deck fans.
- H. Units shall have a draw-through configuration.

2.02 MANUFACTURERS

- A. Huntair / Temtrol (Basis of Design)
- B. Haakon
- C. Or accepted substitution.
- D. Equipment as supplied by any of the acceptable manufacturers or an approved equivalent shall comply with all provisions of the specification.

2.03 UNIT CASING, FRAME, AND GENERAL CONSTRUCTION

- A. Unit Casing:
 1. Panels shall be double wall, reinforced construction with sufficient internal bracing to prevent excessive deflection of the panels.
 2. Exterior walls minimum 16-gage G-90 galvanized steel.
 3. Internal insulation shall be minimum R-value of 12 and fire and fungus proof.
 4. Protect all internal insulation with solid galvanized sheet metal inner panels of minimum 18-gage G-90 galvanized steel.
 5. All sheet metal joints throughout the air-handling unit and between panelized sections shall be gasketed with closed cell, soft rubber gaskets, fabricated from neoprene, EPDM or other approved material.
 6. Where the air unit casing encloses the building columns, provide airtight enclosure. Leakage rate will not exceed that allowed for the unit casing.

7. Maximum deflection at any point on the unit casing shall be limited to $1/200^{\text{th}}$ of the overall panel width or height.
8. Provide a thermal break between exterior panel and frame to ensure an air-tight fit. Configure casing assembly to eliminate all through-metal portions of the unit so that there will be no external condensation.
9. Panel surfaces shall be non-condensing per ASTM D 4230, Measuring Humidity with Cooled Surface Condensation.

B. Drain Pans:

1. Provide IAQ style drain pan under the entire cooling coil section, which is in compliance with ASHRAE Standard 62.
2. Drain pan shall extend minimum 24 inches downstream of the cooling coil section.
3. Construct drain pan of Type 304 stainless steel; minimum 14-gage on 100 percent outside air handling units and minimum 16-gage on recirculating units.
4. Insulate the under side of the entire drain pan with two part sprayed on polyurethane closed cell foam with a minimum of R-14 insulation value. Insulation shall be water impervious rigid type, after curing, and shall occupy all voids and areas between drain pan and outer wall to prevent the occurrence of trapped water, condensation, and microbial growth. Install and seal insulation as is appropriate for the equipment construction.
5. Slope drain pan in all planes to the drain connection to prevent accumulation of standing water. On units over ten (10) feet in width, slope pan to drain on both sides of the unit.
6. Condensate from drain pans shall be piped as indicated on the Drawings. The pipe size shall be 1-inch minimum diameter, insulated as specified for chilled water piping. A trap as required to prevent the escape or entry of air through the drain piping shall be provided as indicated on the Drawings.
7. Provide an insulated intermediate drain pan for all coils above another coil, factory piped to main drain pan. Drain pans shall be sloped and constructed of 16 gage Type 304 stainless steel to match the main drain pan and shall be extended 6 inches from the coil face.

C. Base and Floor:

1. Construct each unit section on a structural base that supports all major components (i.e., fans, coils, etc.). Support with structural steel members.
2. Complete perimeter channel base shall be minimum 6 inches galvanized steel. Select base rail size appropriate to the drain trap depth.
3. Fabricate base of electrically welded structural steel members. Use welding procedures and welders certified for structural steel welding according to AWS D1.1.
4. Base and structural members shall be G120 galvanized steel.
5. Unit floor material thickness is 14-gage, galvanized tread plate insulated with foam insulation equivalent to R-12 or greater. The flooring shall be welded to structural members below. No penetrations through the floor skin shall be acceptable. Welds shall be below the floor and spaced no greater than 6 inches on center.
6. A 20-gage galvanized sheet shall enclose the insulation on the bottom of the unit.

7. All points of contact between the floor, vapor barrier and structure shall be thermally isolated with closed-cell soft rubber or EPDM.

D. Access Doors:

1. Provide access doors to allow access to both sides (upstream and downstream) of filters support frames. Provide air lock access both the (upstream and downstream) of the fan section, and cooling coil section. The air lock must be large enough to allow for the exchange of fan assemblies and components while preventing the infiltration of unconditioned air or the loss of supply air flow to the respective air conditioned spaces.
2. Each fan/motor cube is designed for quick replacement of the fan/motor assembly, and capable of passing through a minimum 30 inch wide, access door located on the discharge side of the fan wall array.
3. Access doors are double wall, insulated the same as wall panels, and the opening framed with thermal break construction.
4. Door size must be at least 18 inches wide and full panel height up to 72-inch tall units. For units above 72 inches tall, provide, 72-inch high doors. For panels over 36 inches wide, provide 36-inch wide doors.
5. Access door construction shall equal or exceed the quality of air handler casing materials as specified herein.
6. Each door has a minimum 8-inch by 6-inch double glazed view window, capable of withstanding the total developed pressure of the unit.
7. Doors are hinged using either heavy-duty adjustable stainless steel butt hinges or a continuous adjustable stainless steel piano hinge, extending along the entire edge of the door, except for a maximum of 2-inches at each end. If butt hinges are used, provide two (2) per door for up to 36-inch high doors and three (3) per door for taller doors. Provide minimum of two (2) latches on doors taller than 18 inches and three (3) latches on doors over 36 inches long. Latches shall be Ventlok 310, heavy-duty latch.
8. All access doors open against positive air pressure, unless they are the outer doors of the air lock entrances or approved by the Owner in writing.

E. Rigging Performance Requirements:

1. Provide units that include lifting lugs and are suitable for rigging without requiring additional support frames or rails.
2. Provide units that may be lifted without permanent deformation to the housing, base or internal components.
3. Indicate physical balance point on unit bases.

2.04 FANS AND RELATED COMPONENTS

A. Fans and Motors:

1. Fan Wall System: The fan wall system shall consist of multiple, direct driven, arrangement 4 plenum fan constructed per AMCA requirements for the duty specified, (Class I, II or III). All fans shall be selected to deliver the specified airflow quantity at the specified operating total static pressure and specified motor speed. The fan wall array shall be selected to operate at a system total static pressure that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed. Each fan/motor "cube" shall include an 11 gage; A60 galvanized steel motor support plate and structure. The fan intake wall, inlet funnel, and motor support structure shall be powered coated for corrosion resistance. All motors are standard T-frame pedestal mounted type, (TEFC), selected at the specified operating voltage, rpm, and efficiency as specified or as scheduled elsewhere. All motors are to be compatible for inverter duty, and include isolated bearing or shaft grounding. To ease the replacement of the assembled fan/motor, the motor must not to exceed the nominal rating of 10 horsepower.
 - a. The fan wall array shall be provided with acoustical silencers to reduce the bare fan noise by a minimum 14 db re 10⁻¹² watts through the eight octave bands with center frequencies of 125, 250, 500, 1000, 2000, 4000 and 8000 hz when compared to same unit without silencers. The silencers shall not increase fan static pressure, nor shall it increase the airway length of the air handling unit.
 - b. Alternate manufacturers must submit acoustical data for review and approval prior to bid indicating the proposed alternate equipment can meet all specified performance requirements. Proposals submitted which indicate a higher connected fan horsepower than specified or scheduled will not be accepted.
2. Multiple Fan/Motor VFD Control: The fan array shall consist of multiple fan and motor "cubes", spaced in the air way tunnel cross section to provide uniform airflow and velocity profile across the entire airway tunnel section and components contained therein. Each fan cube shall be individually wired to a control panel containing power lock-disconnects for individual motor(s) and VFD(s) controlling respective fan motors in the fan array. Each VFD shall be driven by a "master/slave" control scheme and shall be provided with a redundant VFD in the event of a "master" VFD failure. The manufacturer furnishes a spare VFD of the same make and model as the VFD(s) being used to power the array of fans. The VFD(s) and one spare VFD shall be furnished by the AHU manufacturer and shall be protected though a hard wired interlock to allow only one VFD to be energized at a time. Refer to Specification Section 23 05 13 – "Variable Frequency Drives" for requirements. Circuitries for VFD fault /failures, VFD "master" enable, VFD "slave" enable, single fan failure or trip conditions are provided by the manufacturer for connecting with the Owner's building automated system (BAS) for control and monitoring purposes. Connection to the Owner's existing BAS shall be accomplished though hard wire inputs and outputs. Gateway / Interfaces are not allowed. See Fan Array component panel requirements.
3. The fan wall array shall produce a uniform airflow and velocity profile within the airway tunnel of the air handling unit not to exceed the specified cooling coil and filter bank face velocity when measured 12 inches from the intake side of the fan wall array intake plenum wall and at a distance of 48 inches from the discharge side of the fan wall intake plenum wall.
4. Each fan/motor cube is equipped with a metal grating fan outlet guard.
5. Each fan wall array shall also include motor removal rail located on the discharge side of the fan wall array. The rail shall span the full internal width of the unit. A blanked off panel to isolate the inlet side of the fan/motor assembly that is being removed from the fan wall array.

6. Each fan array shall include at least one fan assembly with a complete airflow measuring station to indicate airflow in CFM. The flow measuring system shall consist of a flow measuring station with static pressure taps and total pressure tubes located at the fan inlet cone. The flow measuring station shall provide an analog to digital CFM readout using a 4-20ma or 0-10 volt output control signal for use in the BAS.
7. The manufacturer shall provide a complete spare fan wall fan/motor assembly with each respective air handler.
8. Plug Fan (PF) SWSI Minimum Class II Fans: single width single inlet arrangement 4 as indicated on the Drawings. Fan wheel has a minimum of 12 blades made from extruded aluminum as a hollow airfoil in shape, and welded to the center and wheel side plates. The fan Inlet cone is made from spun aluminum material.
9. Fans shall be both dynamically and statically balanced. Dynamic fan balancing shall be conducted from 16 Hz to 66Hz to identify and eliminate critical speeds to ensure stable operation through the entire operating range of the fan and drive assembly. Fan shaft shall be turned, ground and polished solid steel rated at maximum RPM below critical speed. Fan wheel shall be keyed to the shaft. Fans shall be rated in accordance with AMCA 210 for performance and AMCA 300 for sound.
10. Fan motors are premium efficiency and compatible for inverter duty per Section 20 05 13.

B. Bearings:

1. Antifriction type, either ball or roller, lubricated at the factory and extended lubrication lines where necessary to achieve bearing lubrication or solid silicon nitride (ceramic) bearings.
2. Catalogued type as manufactured by Fafnir, SKF, NTN or Sealmaster; bearings shall be stocked locally.
3. L-10 minimum life of 200,000 hours (direct drive application).
4. Grease fittings for bearings shall be remotely mounted within line of sight of the bearing, where possible. Where line of sight is not feasible, then the fitting shall be mounted with an extended lubrication where it is most easily accessible for service. Stainless steel tubing is used for the remote grease fitting. If the motors are equipped with more efficient solid silicon nitride (ceramic) ball bearings, then lubrication lines are not required.

2.05 COIL SECTION

A. Coil Casing:

1. Coil casing shall comply with requirements for general construction.
2. Coil casing reinforcements shall be furnished so that the unsupported casing length is not over 60 inches. Reinforcements shall be of the same material as coil casing.
3. Coils shall be individually removable by means of a coil rack. The coil support rack shall not be used to provide structural stability for the coil casing. Coil support racks for chilled water coils are to be made of Type 304 stainless steel materials. Coil support racks for hot water coils are to be made of A-36 carbon steel materials. The assembled carbon steel frames are to be coated with hot dipped galvanized material.
4. Coils shall be completely enclosed within the coil casing.
5. All penetrations of the coil casing shall be neatly sealed at the factory using a resilient sealant appropriate for the service temperature.

6. Access doors as specified herein shall be provided for each space between coils, filters, and other components.

B. Steam Coils:

1. All steam coils shall be steam-distributing type non-freeze 1-inch outside diameter seamless copper outer tubes having 0.035-inch minimum wall thickness.
2. Inner tube shall be 5/8 inch outside diameter seamless copper tubes having 0.025-inch minimum wall thickness.
3. Coil shall have 0.008-inch thick aluminum fins suitable for use with steam at a maximum temperature of 400 degrees F and a maximum pressure of 200 psig.
4. Coil headers shall be cast iron or I.P.S. brass or as specified hereinafter for chilled water coils.
5. Coils shall have a maximum of two (2) rows and a maximum of eight (8) fins per inch.

C. Chilled and Hot Water Coils:

1. Water coil capacities, pressure drops and selection procedures shall be certified for the capacity scheduled in accordance with ARI Standard 410-87. Non-certified coils will not be accepted. The cooling coil face velocity shall not exceed 500 FPM. Maximum water pressure drop through coil shall not exceed 20 feet and maximum velocity in tubes shall not exceed 8 feet per second.
2. Chilled Water Coils:
 - a. Extended surface type meeting all conditions and having the minimum face area and pressure drops scheduled on the Drawings. Same-end supply and return connections unless otherwise indicated.
 - b. Coils shall be constructed of copper tubes 5/8-inch [1/2-inch] outside diameter with 0.035-inch thick minimum wall thickness and copper fins permanently bonded to the tubes by mechanical expansion.
 - c. Coils shall have a maximum of eight (8) fins per inch and a maximum of six (6) rows. If additional capacity is necessary, provide an additional coil, with a separate access section between the coils. The coils shall be piped in series, counterflow to the direction of airflow. Copper fins on plate coils shall be 0.006 inch thick.
3. Hot Water Coils:
 - a. Extended surface type meeting all conditions and having the minimum face area and pressure drops scheduled on the Drawings. Same-end supply and return connections unless otherwise indicated.
 - b. Coils shall be constructed of copper tubes 5/8-inch outside diameter with 0.035-inch thick minimum wall thickness and aluminum fins permanently bonded to the tubes by mechanical expansion.
 - c. Coils shall have a maximum of eight (8) fins per inch and a maximum of six (6) rows. If additional capacity is necessary, provide an additional coil with a separate access section between the coils. The coils shall be piped in series, counterflow to the direction of airflow.

4. Coil headers and connections shall be of I.P.S. brass or heavy gage seamless hard drawn copper tubing with penetrations for connection of core tubing by die-formed intrusion process with resulting contact depth between the header wall and core tubing of not less than 0.090 inches. Joints between core tubing and header shall be of recess swage design to allow a large mating area for build up of brazing materials to give increased strength to the joint. Supply and return connection of brass or copper shall be terminated with brass flange connections.
5. Each coil section shall be provided with a Type 304 stainless steel frame/casing, including tube sheets, minimum 16-gage. Frame members shall extend over the ends and edges of the coils and shall be constructed with formed holes for tubes, permitting free expansion and contraction of coil sections while supported by an extended surface of the frame. Intermediate tube support sheets of Type 304 stainless steel shall be provided in all coils having tube lengths in excess of 48 inches. On long coil sections the spacing of coil supports shall not exceed 48 inches. All intermediate supports shall be welded to coil frame members and fabricated with formed tube holes to support the penetrating tubes.
6. Coils shall be leak tested with air pressure under water at 325 psig, and shall be designed for operation at pressures indicated on the Drawings. Maximum working pressure classification is 300 psig. Submit certification of leak test and certification that coils are suitable for testing at pressures of 450 psig at 100 degrees F. Provide stainless steel nameplate on each coil indicating: manufacturer, model number, coil designation, coil medium, coil test pressure, coil maximum operating temperature and pressure.

2.06 FILTER HOUSING

- A. Refer to Section 23 40 00 – Filters, and Drawings for additional requirements.
- B. Filters shall have a maximum width of 24 inches.
- C. Side Access Housings:
 1. Fabricate of not less than 16-gage galvanized steel.
 2. Housings shall each be equipped with hinged access doors at both ends, provision for receiving filters of any manufacturer without alteration to the housings and extruded aluminum channels capable of receiving both the after filters and 2-inch deep panel type prefilters.
 3. Housings shall incorporate a permanent provision for sealing filters against leakage around the entire perimeter of each filter, eliminating the need to purchase replacement filters with factory applied gasket strips.
 4. Replaceable woven pile seals shall be an integral component of the downstream flange of each extrusion so that the seals are compressed by the pressure drop across the filters, preventing bypass of unfiltered air.
 5. Housings shall not exceed 21 inches in direction of airflow and shall be of all welded construction with factory prepunched standing flanges for ease of attachment to adjacent equipment and/or ductwork.
 6. Doors are to be fitted with positive sealing, heavy duty multiple latches and with sponge neoprene gaskets.

- D. Unitary front access holding frames shall be fabricated of not less than 16-gage galvanized steel with holes prepunched for convenient assembly into banks. Frames shall be a minimum of 2-5/8 inches deep for maximum structural strength and resistance to racking. All joints in the field-assembled banks of frames shall be thoroughly caulked to prevent bypass of unfiltered air between frames and surrounding ductwork or plenum chambers. Frames shall each be fitted with polyurethane foam gaskets, held in place by long lasting adhesive and with a minimum of four heavy-duty spring type fasteners. Fasteners shall attach to the frames without requiring tools and shall be capable of withstanding 25 pounds of pressure without deflection.
- E. Housing for disposable carbon panels shall be of modular design with each module designed to hold four (4) carbon panels and four (4) 1-inch type "C" filters in "V" shape. Each module shall also be designed to accommodate one 4-inch Type "C" filter downstream of the four carbon panels and the four Type "C" filters. Housing shall include all necessary hardware to mount panels and filters.
- F. Frames for filters with efficiencies greater than 95 percent shall be constructed of not less than 14-gage stainless steel channel and shall be of all-welded construction, factory fabricated and assembled. Where the size of the filter bank is larger than can be fabricated in a single unit, the manufacturer shall provide modules to minimize the number of field joints.

2.07 DAMPERS

A. Mixing Box Section:

- 1. Factory built, field mounted, outside air and return air dampers of Type 304 stainless steel and edge seals in stainless steel frame, with stainless steel axles in self-lubricating nylon bearings.
- 2. Opposed blade arrangement with damper blades positioned across short air opening dimension.
- 3. Provide removable, full width rack for supporting freeze protection thermostat, with removable end panel to permit rack removal.

B. Damper Leakage:

- 1. Maximum 4.0 cfm per square foot at 4-inches w.g. differential pressure.
- 2. Dampers shall be sized for maximum 2000 FPM face velocity.

2.08 VAV DUAL DUCT SECTION

A. Cold and Hot Decks: Arrange the cold and hot decks to provide maximum recovery of fan discharge velocity head and to ensure uniform airflow across the faces of the cooling and heating coils.

- 1. Balancing Plates: If required provide perforated balancing plates as required to ensure balanced airway resistance between hot and cold air pathways within the unit.
- 2. Integral Air Passages:
 - a. Construct air passages and ducts so as to direct air streams from the heating and cooling coils separately with minimum friction loss as possible within the constraints of the allowable dimensions of the air handling unit's casing.
 - b. Insulate partitions common to both hot and cold air passages and seal the partition airtight.

3. Damper Section:

- a. Provide opposed-blade, interlocking dampers of heavy gage steel, pivoted on their longitudinal axes in nylon bearings.
- b. Arrange hot and cold air dampers for opposed action and secure to shafts.
- c. Face areas of damper sets will be in proportion to the indicated zone air quantities.

2.09 AIR HANDLING UNIT SPECIALTIES

A. Steam Grid Humidifiers: Refer to Section 23 84 13. The humidifier section shall be designed and constructed to meet the same criteria as the rest of the air handling unit sections. The humidifier section length shall be as specified on Drawings.

B. Variable Speed Drives (VSD):

1. Refer to Section 23 04 10.
2. Where indicated on Drawings, furnish as a part of the unit assembly, with drive matched to motor without noise or vibration over the entire operating range.
3. All motors with VSDs shall be compatible with VSD and tested at the factory.
4. Drives shall be erected on wall where shown on Drawings with support from floor.

C. Ultra Violet Germicidal Irradiation Systems:

1. Where scheduled on the Drawings, provide factory installed Ultra Violet (UV) Germicidal Irradiation lamps. Lamps shall provide a minimum irradiance of 9 Watts per square foot or 96.54 Joules per square meter at the cooling coil surface and at the coil leaving air temperature scheduled on the Drawings.
2. UV lamps shall be located:
 - a. Downstream of cooling coils.
 - b. Above condensate drain pans.
 - c. Up-stream of final filtration sections.
3. Lamps shall be UL listed for application in air handling systems.
4. Lighting systems shall be vapor proof with electronic ballasts and shall be wired.
5. UV Light fixtures shall be capable of being switched on and off at the respective AHU section access door.
6. Lamps shall be interlocked with access door position limit switches such that they are de-energize when the doors open.
7. Lamps shall be installed on a stainless steel grid in accordance with the manufacturer's installation instructions.
8. Units with view ports from which the lamps can be seen shall be labeled to warn of possible eye damage.
9. Replacement lamps for UV systems shall be standard types which are not proprietary and are available from multiple sources.

2.10 SOUND CHARACTERISTICS

- A. Conduct sound tests at the unit manufacturer's test facility under AMCA Guidelines and Conditions.
- B. Provide sound power level test procedures and data for each unit under scheduled operating pressures.
- C. The air handling unit sound power levels must not exceed the following criteria. Sound power levels scheduled on Drawings shall supercede the values below:
- D. [Note to Engineer: The sound power levels provided in the following table must be carefully examined for each unit on each project. This table represents a starting point only for coordination between the acoustics specialist and the unit manufacturer.]

Location	Average	63 HZ	125 HZ	250 HZ	500 HZ	1K HZ	2K HZ	4K HZ	8K HZ
Units from 10,000-15,000 cfm (Where specifically applicable)									
Inlet	84	83	81	81	79	78	77	75	73
Outlet	91	91	84	92	88	86	80	76	72
Casing	71	85	77	77	66	60	54	51	48
Units from 15,001-25,000 cfm (Where specifically applicable)									
Inlet	85	84	86	80	80	81	78	74	67
Outlet	93	94	90	92	92	89	82	79	74
Casing	72	84	81	78	68	62	56	53	48
Units from 25,001-35,000 cfm									
Inlet	87	84	92	87	83	81	78	77	73
Outlet	94	92	95	97	92	87	82	79	74
Casing	73	83	85	78	66	59	54	52	48
Units from 35,001-45,000 cfm									
Inlet	93	94	96	90	89	89	82	76	72
Outlet	95	97	95	96	95	89	82	80	75
Casing	78	92	88	83	73	66	57	53	49
Units from 45,001-55,000 cfm									
Inlet	84	101	97	83	77	75	68	65	64
Outlet	95	98	98	95	94	89	80	76	92
Casing	77	94	90	80	68	60	55	53	49
Units from 55,001-65,000 cfm									
Inlet	89	92	97	88	87	84	77	71	68
Outlet	98	103	103	98	96	92	90	78	74
Casing	78	93	92	81	71	64	59	49	46
Units from 65,001-75,000 cfm									
Inlet	95	100	102	95	93	89	86	83	78
Outlet	95	100	102	95	93	89	86	83	78
Casing	77	96	91	78	66	59	55	53	49
Units from 75,001-larger cfm									
Inlet	87	105	99	85	81	78	70	68	68
Outlet	96	102	103	97	94	90	86	84	79
Casing	79	99	92	79	67	60	55	54	50

2.11 FAN WALL COMPONENT PANEL REQUIREMENTS

- A. The AHU component panel shall be designed and constructed to meet the functional intent as follows:

1. Design of the Component Panel General:
 - a. Compliance with all applicable codes and regulations.
 - b. DDC or PLC controllers shall not be utilized.
 - c. Short circuit and over current protection shall be manually reset.
 - d. All safeties, relays, and field wiring shall be fail-safe.
 - e. Provide electrical disconnect means for each fan in the fan array.
 - f. Current sensors shall be split core with LED indicator and field adjustable per fan.
 - g. Plug in pin relays with status LED shall be provided.
 - h. Provide "Push to Test" lamp push button.
 - i. Panduit or equivalent shall be utilized for panel wiring.
 - j. Termination strips, contactors, relays, current sensors, switches, and any other apparatus shall be labeled in approved manner as deemed by the Owner.
2. Design of the Component Panel VFD:
 - a. The variable frequency drive LCD displays and H-O-A switch(es) and shall be readily accessible.
 - b. The variable frequency drive H-O-A switches in the Hand position shall activate all required HVAC apparatus (e.g. outside air damper, isolation damper, etc) The VFD shall start the fan array after apparatus position indications and safeties are in an acceptable state.
 - c. The variable frequency drive H-O-A switch(es) on the VFD in the Auto position shall start and stop the VFD through the BAS. The VFD shall activate all required HVAC apparatus (e.g. outside air damper, isolation damper, etc) The VFD shall start the fan array after apparatus position indications and safeties are in an acceptable state.
3. Design of the Component Panel Termination Strip:
 - a. A termination strip shall be provided for Division 26 life safety field wiring. This termination strip shall have an AHU shutdown, supply smoke, and return smoke input terminals. The life safety shutdown relay shall be wired in series to these terminals. Division 26 shall supply, install, and wire field devices including installing a jumper wire for any life safety terminals not utilized in the project. An indication light mounted in the component panel door shall display the life safety relay status.
 - b. A termination strip shall be provided for Division 25 HVAC safety field wiring. This termination strip shall have a high static pressure and coil freeze protection safety input terminals. The equipment safety shutdown relay shall be wired in series to these terminals. Division 25 shall supply, install, and wire the high static safety and freeze protection devices to the terminal strip, including installing a jumper wire for any HVAC safety terminals not utilized in the project. An indication light mounted in the component panel door shall display the HVAC safety relay status. High static safety and freeze protection status outputs shall be provided in the component panel for the BAS.

- c. A termination strip shall be provided for Division 25 BAS field control wiring. This termination strip shall have but not limited to a VFD Start/stop input, VFD speed input, VFD speed feedback output, VFD fault output, VFD control apparatus outputs and inputs. Division 25 shall supply, install and wire to the terminal strip the VFD control apparatus outputs and inputs (e.g. damper end switches, actuators and dampers not supplied with the AHU).
 - d. Each fan in the fan array shall have a current sensor wired to the BAS field wiring terminal strip. Division 25 shall series all current sensor at the termination strip to create one BAS fan status input or series specific fans as necessary to comply with the sequence of operation.
4. Functional Intent of the Component Panel
- a. The component panel functional intent is manual operation of the fan array which is independent from the building automation system and automated control for the VFD by the building automation system. The component panel shall provide all life safety and HVAC equipment safeties AHU shutdown interlocks wired to termination blocks. The component panel shall be designed using only ladder logic hard wired methods and shall not execute any programmed logic specified in the sequence of operation which cannot be submitted in a ladder wiring diagram. The component panel shall provide all relevant inputs and outputs necessary for the building automation system to execute the specified sequence of operation.
 - b. Coordinate component panel design with Division 25. Submit best design for owner approval prior to construction of component panel. Laminate final approved as-built ladder wiring diagram and mount inside component panel door.

2.12 ELECTRICAL PROVISIONS

- A. Fan motors shall be factory mounted and wired to an external disconnect switch within sight of the motor access door. Fan motors shall be interlocked with fan access door to shut down fan when door is opened.
- B. Disconnect switches and starters shall be mounted independent of the unit to allow for maintenance access and access to AHU components. Locate disconnect switches within close proximity and sight of the electrical component. Interlock fan motor starters with a position limit switch located at the fan section access door. The limit switch shall de-energize the fan motor or other electrical components when the access door is opened.
- C. Provide vapor-proof, two-lamp linear fluorescent light fixtures with electronic ballasts, and water proof GFI convenience outlets inside sections before and after coil; before filter, at fan and before silencer compartments. Light fixtures in each air handling unit compartment shall be independently switched. Wire lights and outlets to two external 120V, 20A power connections (one for each service) for connection by Division 26. Fixtures and lamps shall comply with Division 26 requirements.
- D. All wiring shall be 600V rated type MTW/THWN #12 stranded copper in EMT or LiquidTite conduit (maximum three feet). All junction boxes shall be UL approved and gasketed. All conduits installed on the floor inside air handling units shall be rigid steel with steel fittings and diecast boxes. All EMT conduit and fittings on unit walls and ceiling shall be steel, watertight type.
- E. Provide flexible connection to motor; 36-inch maximum length.
- F. Conduit penetrations shall not represent through-metal contact. Penetrations shall be made and sealed before unit factory testing.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Install in conformance with ARI 435.
- D. Install factory assembled unit on vibration isolators, where fans are not internally isolated. Refer to Section 20 05 48.
- E. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation of the Owner's representative(s).
- F. Provide the minimum access space sections for maintenance of individual components such as fans, filters, coils, humidifiers, etc., as scheduled or shown on the Drawings. Arrange these components in a manner that allows for ease of replacement. Provide a plenum section downstream of the cooling coil with sufficient width to contain all the moisture carryover from the cooling coils, before it reaches the next air handler component (such as filters, sound attenuators, etc.).
- G. Arrange fans and surrounding components in such a way that poor fan performance does not result.
- H. It is the manufacturer's responsibility to verify opening dimensions and installation methods to ensure unit sections and components can be physically installed into the designated space.
 - 1. The manufacturer has the responsibility to transport sections to the Project Site and to supervise reassembling the sections together for all air handlers. Unload and hoist the sections onto the designated floor space.
 - 2. Reassemble the sections together for all air handlers in their footprint under the direction of the manufacturer.
 - 3. Additional unit section or component splits required for installation during construction shall be the responsibility of the manufacturer without additional cost to the Owner.
 - 4. Units must be bolted together for reassembly. Drive screw construction at unit splits is unacceptable.
 - 5. All internal coil piping shall be extended to casing walls.
 - 6. The unit manufacturer shall provide a written acceptance letter to MDACC stating the unit was assembled and complies with manufacturer's assembly requirements.
- I. Support coil sections independent of piping on steel channel or double angle frames and secure to casings. Provide frames for maximum three coil sections. Arrange supports to avoid piercing drain pans. Provide airtight seal between coil and duct or casing.
- J. Protect coils to prevent damage to fins and flanges. Comb out bent fins.
- K. Install cleanable tube coils with 1:50 pitch.
- L. Make connections to coils with unions and flanges.

- M. On water coils, provide shut-off valve on supply line and lockshield balancing valve on return line. Locate water supply at bottom of supply header and return water connection at top. Provide float operated automatic air vents at high points complete with stop valve. Ensure water coils are drainable and provide drain connection at low points.
- N. On water heating coils and chilled water-cooling coils, connect water supply to leaving airside of coil (counterflow arrangement).
- O. In steam coils, install vacuum breaker in steam line at header. Install steam traps with outlet minimum 12 inches below coil return connection. Install dirt leg in steam supply.
- P. Insulate headers located outside airflow as specified for piping. Refer to Section 20 07 19.
- Q. Ensure sufficient space between coil sections for installation of control devices.

3.02 TESTING

- A. Units with cabinet mounted fans shall be tested and certified at rated conditions using AMCA test procedures with fan mounted in the cabinet. Bare fan data will not be accepted.
- B. With unit set in place, leveled and ready to receive ductwork connections, unit shall be tested for casing leakage by sealing all openings and pressurizing to 2 inches w.g. above unit rating or the rating of attached ductwork or a maximum of 12 inches w.g. Maximum allowable leakage rate is 1 percent of design airflow.
- C. Test shall be performed by the manufacturer using certified flow measurement devices and shall be witnessed by a representative of the Test and Balance Firm. Demonstrate deflection limit of 1/200th and confirm fan/motor vibration limits. The cost of testing shall be borne by the manufacturer.
- D. After assembly, fan and motor shall be given an electronic vibration analysis along with the variable speed drive (if applicable), either at the air handling unit or VSD manufacturer's factory, while operating over the entire speed range.
- E. Vibration amplitude and frequency shall be recorded in the horizontal, vertical and axial planes.
 - 1. Maximum allowable variation amplitude is 1.0 mil. Full range of frequencies (500 to 50,000 cycles per minute) shall be scanned to detect misalignment, bearing defects, mechanical looseness or foundation weakness.
 - 2. Each bearing shall be tested.
 - 3. Fans with VSDs shall be checked from 15 percent to 100 percent of the rated speed.
 - 4. "Lock-out" ranges may be used to correct up to two ranges of excess vibration. The span of each "lock-out" range shall be limited to an effective fan speed of 50 RPM. Any "lock-out" ranges used shall be clearly identified in the test report and shall be prominently displayed on a typed, laminated legend mounted inside the VSD controller cabinet.

3.03 AIR HANDLING UNIT SUBMITTAL DATA

- A. The information for each item listed below must be furnished as part of these shop drawing submittals. Additional data may be submitted on separate sheets. Submit the requested data on the forms provided. Provide data for the air-handling units noted on the Drawings.
- B. General Data:
 - 1. Air Handling Unit Manufacturer

2. Maximum Exterior Dimensions (Assembled)
 - a. Length (feet)
 - b. Width (feet)
 - c. Height (feet)
 - d. (Attach general arrangement drawing.)
 3. Operating weight (pounds)
- C. Filters:
1. Manufacturer
 2. Type
 3. Efficiency (percent)
 4. Quantity
 5. Pressure Drop
 - a. Clean
 - b. Dirty
 6. (Attach manufacturer's literature.)
- D. Final Filters:
1. Manufacturer
 2. Type
 3. Efficiency (percent)
 4. Quantity
 5. Pressure Drop
 - a. Clean
 - b. Dirty
 6. (Attach manufacturer's literature.)
- E. Preheat Coil:
1. Manufacturer
 2. Air Flow (cfm)
 3. Face Velocity
 4. Air Entering Temperature (degrees F)
 5. Air Leaving Temperature (degrees F)
 6. Fins per Inch (9 maximum)

7. Rows (2 maximum)
8. Minimum Capacity (Btuh)
9. Rated Capacity (Btuh)
10. Steam Flow (lb./hr)
11. Air Pressure Drop (Inches w.g.)
12. Tube Diameter (Inches)
13. Tube Material
14. Fin Height
15. Fin Material
16. Tube Wall Thickness
17. Coil Section Dimensions (Inches)
18. Coil Weight
19. Frame Material

E. Fan Sound Power (at design cfm)	at AHU Inlet	at AHU Outlet
1st Octave	_____	_____
2nd Octave	_____	_____
3rd Octave	_____	_____
4th Octave	_____	_____
5th Octave	_____	_____
6th Octave	_____	_____
7th Octave	_____	_____
8th Octave	_____	_____

20. Fan BHP (at design cfm)
 - a. (with clean filters)
21. Fan BHP (at design cfm)
 - a. (with fully loaded filters)
22. Motor Horsepower
23. Motor Efficiency (at design cfm)
24. Motor Efficiency (at 50 percent of design)
25. Motor Manufacturer and Model Number
26. Bearing Manufacturer and Model Number
27. Attach Manufacturer's Literature on:
 - a. Fan

- b. Fan Curve at full RPM (design cfm)
- c. Fan Curve at minimum recommended RPM
- d. Motor
- e. Fan Bearings
- f. Fan Drive
- g. Vibration Isolation
- h. cfm vs. Total Unit kW Curve with Clean Filters for Fan
- i. cfm vs. Total Unit kW Curve with Fully Loaded Filters for Fan

F. Cooling Coil:

- 1. Manufacturer
- 2. Air Flow (cfm)
- 3. Face Velocity
- 4. Air Entering Temperature (degrees F)
 - a. Dry Bulb
 - b. Wet Bulb
- 5. Air Leaving Temperature (degrees F)
 - a. Dry Bulb
 - b. Wet Bulb
- 6. Fins per Inch (8 maximum)
- 7. Rows (6 maximum)
- 8. Minimum Coil Capacity Sensible/Total (Btuh)
- 9. Rated Coil Capacity (Btuh)
- 10. Entering Water (gpm)
- 11. Entering Water Temperature (degrees F)
- 12. Leaving Water Temperature (degrees F)
- 13. Water Side Pressure Drop (Feet w.g.)
- 14. Air Side Pressure Drop (wet) (Inches w.g.)
- 15. Water Velocity (ft/min)
- 16. Number of Sections
- 17. Tube Diameter (Inches)
- 18. Tube Material

19. Fin Height
 20. Fin Material
 21. Tube Wall Thickness
 22. Coil Section Dimensions (Inches)
 23. Coil Weight
 24. Frame Material
 25. Finish
- G. Heating Coil:
1. Manufacturer
 2. Air Flow (cfm)
 3. Face Velocity
 4. Air Entering Temperature (degrees F)
 5. Air Leaving Temperature (degrees F)
 6. Fins per Inch (8 maximum)
 7. Rows (2 maximum)
 8. Minimum Coil Capacity Sensible/Total (Btuh)
 9. Rated Coil Capacity (Btuh)
 10. Entering Water (gpm)
 11. Entering Water Temperature (degrees F)
 12. Leaving Water Temperature (degrees F)
 13. Water Side Pressure Drop (Feet w.g.)
 14. Air Side Pressure Drop (wet) (Inches w.g.)
 15. Water Velocity (ft/min)
 16. Number of Sections
 17. Tube Diameter (Inches)
 18. Tube Material
 19. Fin Height
 20. Fin Material
 21. Tube Wall Thickness
 22. Coil Section Dimensions (Inches)
 23. Coil Weight

University of Houston
Insert Project Name

24. Frame Material

25. Finish

H. Flow Element:

1. Type

2. Certified Accuracy

3. Pressure Drop

END OF SECTION 23 73 23

SECTION 23 74 20 - CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide field or factory-assembled air handling units and components as shown, scheduled, and indicated on the Drawings.
- B. Types: The types of air handling units required for this project include:

[edit to suit project]

1. Single-zone constant volume indoor air handling units.
2. Single-zone variable air volume indoor OA pretreat air handling units.
3. Single-zone variable air volume indoor air handling units.
4. Double duct indoor air handling units.

1.3 QUALITY ASSURANCE:

- A. Manufacturer: Provide products complying with these specifications and produced by the following:

[edit to suit project]

1. Haakon.
 2. Engineered Air.
 3. ClimateCraft.
 4. Energy Labs.
 5. Temtrol
- B. Coil Certification: Coils shall be designed and rated in accordance with ARI Standard 410.
 - C. AMCA Seal: Fans shall be designed and rated in accordance with AMCA Standards and shall bear the AMCA Seal
 - D. Vibration Testing: Factory-vibration testing shall be provided as specified in Paragraph 2.1/B.
 - E. Pressure Leakage Testing: Coils shall be factory leak tested as specified in Paragraph 2.03/A.
 - F. **[Damper Leakage: Dampers shall be factory-certified per AMCA Standard 500Ä74.]**
 - G. Acoustical Testing: Provide acoustical acceptance testing in a mocked up project installation as specified in Paragraph 2.11.
 - H. **[Unit Run Test: Factory run test entire unit at design speed and simulated discharge static pressure and furnish report for housing integrity (panel deflection), leakage, acoustical acceptability, vibration, electrical system operation, module fit, workmanship and finish appearance prior to shipment from the factory. A complete vibration spectrum shall be conducted as specified in the section covering the fan described hereinbefore. Any fan, motor, drive and base assembly vibration shall be brought to within specified levels prior to unit shipment. Fan tests as conducted in the fan supplier's shop are not acceptable. Motor and drive vibration must be checked with the fan installed as a total assembly.]**

- 1.4 Ifactory-testing for vibration, acoustical performance and unit run testing shall be witnessed by the Owner's Representative. The Contractor shall pay for air fare, accommodations, and similar expenses so that two Owner's Representatives can witness the test.
SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
1. Certified drawings showing overall dimensions of complete assembly, weights, support requirements, sizes, location of connections, accessories, and parts list.
 2. Cut sheets on all air handling equipment, clearly marked to show sizes, configuration, construction, features, accessories and other pertinent information.
 3. Curves showing fan performance and system operating point plotted on curves. Data to substantiate that fan can operate in a stable range with a static pressure 1/2" above that schedule, and that the fan motor is sized accordingly.
 4. Coil performance selection data showing all criteria identified on equipment schedule. Certify the coils will meet performance criteria on equipment schedules.
 5. Bearing sizing calculations for each similar size and type of unit. Fan bearing calculations shall be based on fan at maximum operating conditions.
Complete information on the Variable Air Volume modulation method to be furnished.
 6. Required torque for all motor-operated dampers information on shaft sizes and location in unit and amount of space available for motor operators.
 7. Performance certifications based on applicable ARI Standards and prototype unit test reports.
 8. Prototype sound power levels for each size and type of air handling unit at operation conditions specified. Sound levels shall be in all eight octave bands for: discharge off unit, inlet to unit, and radiated noise through fan section casing. Proposed test mockup layout and testing procedure for unit sound level acceptance testing.
Detailed shop drawings showing all dimensional data, including, but not limited to, gauges of sheet metal, panel reinforcing, size and weight per linear foot of structural base members, floor reinforcing, base reinforcing at internal equipment supports, construction details, damper information, filter frames, etc. Information shall be complete in all respects necessary for Architect/Engineer to evaluate the complete construction of the unit.
 9. Performance certifications based on applicable ARI Standards and prototype unit test reports.
 10. Product warranties and guarantees.
 11. Wiring diagrams.
 12. Written instructions for installation including assembly where not factory-assembled.
 13. Motor data as required in Section 23 04 00.
 14. Additional information as specified in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver air handling units in factory-fabricated water-resistant wrapping.
- B. Handle air handling units carefully to avoid damage to material components, enclosure, and finish.
- C. Store air handling units in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. Single Zone Draw-thru Type Air Handling Units: Provide draw-thru type air handling units complete with sound attenuating housing, plug fan section, adjustable blower drive for balancing and fixed drive for permanent installation with motor mounted on resilient base, V-belt drive with guard, fan intake plenum, access sections, pre-filter section, final filter air filter sections, cooling coil section, condensate drain pan, **[heating coil section,] [preheat and reheat coil sections,]** outside air damper (outside air units only) and other attached sections indicated on Drawings, specified herein or required to accomplish the specified control sequences.

- B. **Double Duct Air Handling Units:** Provide blow-thru type air handling units complete with sound attenuating housing, fan section, adjustable blower drive for balancing and fixed blower drive for permanent installation with motor mounted on resilient base, V-belt drive with guard, air filter section, cooling coil section, **[heating coil section,]** air distribution grid, **[bypass section with equalizing baffles,]** condensate drain pan, and other attached sections indicated on the Drawings, specified herein or required to accomplish the specified control sequences.
- General Construction: Fans, sheaves, motors, and belts shall be factory-assembled and balanced with the fan section casing. Air handling unit fans, bearings, and fan sheave shall be balanced to a maximum of 2 mil in all axes and shall be so certified by the manufacturer prior to installation. The manufacturer shall conduct vibration tests on all units after they have been installed in the field. Vibration shall not exceed 2 mils in all axes and shall be so certified by the manufacturer in writing prior to placing the unit in service. Replace all components that cannot meet these balance and vibration requirements. Unit shall be constructed with the required field splits for rigging, installation and assembly on the jobsite.
- Capacity: Unit characteristics, size, type, capacity, and arrangement shall be as scheduled and shown on the Drawings. Unit shall be capable of stable operation at a static pressure 1/2" above that scheduled and the fan motor shall be sized accordingly.

2.2 HOUSING:

- A. General: Housing shall be airtight, of sectionalized, double wall design with suitable gaskets between sections. Materials shall be phosphatized, bonderized or galvanized steel of lock-forming quality. Steel angle framework shall be designed to provide maximum rigidity, prevent pulsation and shall be of the same finish as the housing. Housing shall include fan section and coil sections with drain pan.
- B. **[Interior Perforated Liner (Downstream of Final Filters): Each unit shall be constructed with an interior perforated liner which shall protect the insulation while allowing acoustical absorption. Insulation shall have a continuous covering of Tedlar film under the perforated liner such that there is not any insulation directly exposed to the air stream downstream of final filters. Liner shall be electrically and thermally insulated from the galvanized steel housing to prevent galvanic action of the two dissimilar metals by use of an acrylic/sealant. Perforated liner shall be 0.030" thick aluminum.]**
- [Interior Perforated Liner (Except Downstream of Final Filters): Each unit shall be constructed with an interior perforated liner which shall protect the insulation while allowing acoustical absorption. Liner shall be electrically insulated from the galvanized steel housing to prevent galvanic action of the two dissimilar metal by use of an acrylic adhesive/sealant. Perforated liner shall be 0.030" thick aluminum.]**
- C. Finish: Galvanized metal shall not be painted. Phosphatized or bonderized metal shall be finished with rust-inhibiting paint.
- D. Coil Section: All connections, coil headers, and return bends shall be completely enclosed. Coil frames shall not be used as reinforcing for the housing. Construction shall be such that the coils can be removed through access panels without affecting the structural integrity of the casing.
- E. Drain Pan: Provide a rigid and watertight positively sloped IAQ drain pan with pipe drain connection under the complete coil section on horizontal units and under the fan and coil section on vertical units. Drain pan shall be of the double pan insulated type with a 316L stainless steel inner pan and a galvanized or painted steel outer pan. Insulation shall be one inch (1") thick, high density fiberglass cemented and vapor sealed between the inner and outer pan or 1/2" thick foamed in place, closed cell insulation. A 316L stainless steel intermediate condensate drip pan shall be provided on all coils over 48" high. Intermediate drain pans shall be factory-piped to main condensate drain pan. Drain pans shall be positively sloped internally to external drain connections as shown on the Drawings.
- F. Access Doors: Provide windowed access doors a minimum of 3/4 of a square foot, but no larger than 6 square feet in size, in the fan and coil sections for inspection and/or access to internal parts. Doors with one dimension 12" or less, shall be equipped with Ventlok Style 100 latch. All other doors shall be equipped with Ventlok Style 140 latch and Ventlok Style 150 hinges. Locate door to allow inspection regardless of mounting arrangement. Door insulation shall be separate from unit insulation and shall be secured and sealed to the double wall constructed door. All access doors shall include 8" x 8"

(minimum) dual pane with wire mesh observation window. Fan section access doors shall be equipped with a factory-installed and wired blower motor / access kill switch.

- G. Insulation: Housings for double wall units shall be thermally and acoustically insulated with minimum two inch (2"), 1-1/2 pound density Manville "Lina-Coustic", "Exact-O-Mat", "Tuf-Skin", or "Aeroflex 200B". All exposed parts such as angles, braces, and similar items in contact with exterior surfaces shall be covered with insulation to prevent condensation on the exterior casing. Insulation shall be installed to allow panel removal without disturbing insulation. Where condensation may occur the exterior wall shall be aluminum, stainless steel or a coated metal to prevent corrosion. Insulation shall be installed between the panel walls to prevent air flow over the insulation and to allow removal without disturbing the insulation. All insulation shall have a composite fire and smoke hazard rating as specified in Section 15200, "System Insulation".

2.3 COILS:

- A. General: Coils shall have capacities and ratings as scheduled and shall be rated by the manufacturers in accordance with ARI Standard 410. Non-certified coils will not be acceptable.
- B. Core Construction: Coils shall be constructed of copper tubes with [aluminum] [or] [copper] plate fins with a maximum of **[8] [12] []** fins per inch and shall be arranged for counterflow operation.. Fins shall be bonded to the tubes by means of mechanical expansion of the tubes. Supply and return connections shall be on the same end of the coil. Tubes shall be 1/2" or 5/8" OD spaced approximately 1-1/2" apart, with a minimum wall thickness of **[0.020"] [0.024"] [0.035"]**. Flat fins shall have a minimum wall thickness of 0.0055". Tapered smooth fins shall taper in thickness from 0.01" at point of contact to 0.005" at the periphery.
- C. Headers: Coil headers and connections shall be constructed of heavy wall copper or admiralty brass. Joints between core tubing and headers shall be of a recessed swage design to provide a large mating area for brazing. Supply and return connections shall be terminated NPT threaded connections with wrench flats.
- D. Casings: Coil casings shall be constructed with structural angle shapes bolted with stainless steel bolts and rigidly supporting the coil assembly. Casing frame members shall extend over the ends and edges of the coil and shall have formed holes for tubes, permitting free expansion and contraction of coil components. Intermediate tube supports shall be provided such that maximum unsupported tube length does not exceed 48". Casings, including all supports and frames, shall be constructed of 316L stainless steel **[for all cooling coils] [and preheat coils] [and] [galvanized steel]** for all **[heating]** coils.

Miscellaneous Requirements:

1. Coils installed in series shall have a minimum of **[12"] [18"] []** between the faces with provisions for access between the faces for cleaning.
 2. Provide internal light for each access, coil and fan section. Light shall be vaporproof with glass globe and guard. Lights shall be prewired to a 120 volt external disconnect switch. 120 volt 15 amp circuit shall be furnished by Division 16.
 3. Provide 12 ga. galvanized steel treadplate for all floor spaces of access sections and fan section.
 4. Provide drain and air vent connections, except where the coil header piping is designed to be self-venting.
 5. Test coils by air pressure under water at 1-1/2 times the pressure classification indicated on the Plans. The test pressure shall in no case be less than 250 psig, nor more than 500 psig.
- E. Chilled Water Cooling Coils: Coils shall be a minimum of **[minimum] [maximum]** of **[six] [eight]** rows deep or as scheduled. **[Where more rows are required, multiple coils shall be provided.]** Cooling coil capacity, maximum face velocity, and maximum air pressure drop shall be as scheduled. Water velocity in the tubes shall not exceed 5' per second and the water pressure drop through the coil shall not exceed **[10'] [20']**, unless lower maximums are scheduled. All cooling coils shall be installed in a vertical position (perpendicular to airflow) to minimize condensate carry over. Coils shall be designed and certified by the manufacturer to operate at the scheduled face velocity plus 10% without moisture carry over.

- F. Hot Water Heating Coils: Coils shall be furnished in the unit where scheduled and shall have a minimum of two rows. Heating coil capacity, maximum face velocity and maximum air pressure drop shall be as scheduled. Coils shall be installed in the bypass or heat position, except in outside air units where the coils shall be in the preheat position. Water velocity in the tubes shall not exceed 5' per second and water pressure drop shall not exceed 10', unless lower maximums are scheduled.
Steam Heating Coils: Coils shall be furnished in the unit where scheduled and shall have a minimum of two rows or as scheduled. Heating coil capacity, maximum face velocity and maximum air pressure drop shall be as scheduled. Coils shall be installed in the heat position, except in outside air units where the coils shall be in the preheat and reheat positions.
- G. Bypass Deck Baffle: On dual duct units, the coil position on the neutral deck shall have a perforated stainless steel plate installed in lieu of a coil. The plate shall be rigidly mounted and shall have an air pressure drop equal to the cold duct cooling coil.
Coil Access/Pull: All hot water and chilled water coils shall include a removable cover plate mounted in the side of the unit casing for future coil repair/removal. This cover plate shall be located on the side of the unit required for coil removal with the unit installed as shown on the Drawings. The Contractor and unit manufacturer shall coordinate exactly where coil access cover must be located on each unit. All unit submittal drawings must show the access cover. The access cover shall be the same gauge as the unit housing, with gasket or sealant strips and attachment screws provided.
- H. MOTORS/ELECTRICAL:
General: Motors shall be open drip-proof (ODP), 3-phase, 1750 rpm, unless noted or scheduled otherwise. All motors shall be premium efficiency type. Motor selection shall be such that the motor will not overload if the static pressure drops 1/2" below or rises to 1/2" above the specified value. Motors shall be mounted on the coil connection side, unless indicated otherwise and the motor shall be mounted on an adjustable base rigidly supported to the unit. The motor shaft shall accommodate an adjustable pitch motor sheave. Refer to Section 23 04 00 for additional motor requirements. All motors shall be factory mounted and wired to an external junction box.
[Lighting and Power: Provide a minimum of one vapor-proof fluorescent light fixture in each module. Module light shall be controlled from a light switch. [Each module will be provided with one convenience outlet, at the inside of each door.] Wiring from lights fixture to switch shall be by unit manufacturer. Unit light fixture [and receptacles] shall be factory-wired to a single external junction box for a single circuit 120 volt, 20A power connection by Division 16.]
Wiring: All wiring shall be 600 volt rated type THHN/THWN stranded copper, enclosed in EMT or Liquidtight flexible conduit (maximum 3'). All junction boxes shall be UL-approved and gasketed.

2.4 FANS AND DRIVES:

- A. Centrifugal Fans: Provide double width, double inlet, multiblade type fans with air foil, forward curved or backward inclined blades, as scheduled. All fans shall be statically and dynamically balanced and tested after being installed on properly sized shafts. Fan shafts must not pass through their first critical speed as unit comes up to rated rpm. Fan wheels and scrolls shall be constructed of galvanized steel, all aluminum or fabricated steel protected with two coats of rust-inhibiting paint. Wheels and scrolls of fans used for outside air service shall be coated with two coats of fire resistant epoxy paint. Fan and fan drive shall be internally spring isolated.
- B. Drives: Select drives for a minimum belt horsepower capacity of 150% of the motor nameplate horsepower. Provide selection calculations with the drive submittal. The selection calculations shall include the correction factor for arc of contact.
- C. Sheaves: Permanent fan sheaves shall be nonadjustable with removable machined bushings, machined on all contact surfaces. Sheaves with over three grooves shall be dynamically balanced and so designated on each sheave. Fan sheaves with three grooves or less shall be statically balanced and if weights are required, they shall be welded to the sheave. Sheaves shall be manufactured by Browning, Eaton Yale and Towne, Dodge Manufacturing Company or Fort Worth Steel and Machinery Company. Provide Browning Type LVP, MVP, or approved equal, adjustable-type with double locking feature. Motor sheave shall be selected for the fan rpm determined by the fan capacity scheduled and shall be adjustable to as close as 10% above and below the rated fan speed. Furnish and install fixed sheaves on units that require more than two belts, after correct speed has been determined with the variable sheave.

- D. Belts: Provide "V-groove" type suitable for the service intended with the capacities specified. Belts shall be closely matched and tagged for use prior to shipment. Recheck belts for proper match during operation and if necessary, replace with closely matched belt sets. Belts shall be Gates, Durkee-Atwood, Goodyear, Uniroyal or Browning.
- E. Shafts: Provide one piece design shafts, either solid or hollow tube with solid stub. Hollow tube with solid stub shafts shall be hot-formed, stress relieved, and manufactured by Pittsburgh Tubular Shafting, Inc. Fans and shafts shall not pass through their first critical speed as the unit comes up to rated rpm.
- F. Shaft Bearings: Provide externally or internally mounted grease lubricated, self-aligning ball or roller bearings on each end of the shaft. Bearings shall have an average B-10 life as defined by AFBMA of 200,000 hours at design operating conditions. All bearings shall be the same size. Internally mounted bearings shall have grease lines extended so as to be readily accessible from the drive side of the unit. In addition, the bearing on the drive end of the shaft shall have grease line extended beyond the belt guard. All grease lines shall terminate in a zerk fitting. Bearings shall be by SKF, Sealmaster, Timken, or Fafnir.
- G. Vibration Isolation: All units shall be internally spring isolated and mounted on pipe columns with ribbed neoprene pads.

2.5 BELT GUARDS:

- A. General: Provide belt guards for all fan drives mounted outside the unit housing. The finish of the guard shall be similar to that of the unit housing. Brace and fasten guards to prevent objectionable vibration. Provide tachometer openings at least 2" in diameter for checking fan and motor speeds. Openings shall be centered on shafts to allow checking rpm.

2.6 FILTERS:

- A. General: Provide, as a part of the factory package, filter sections to accommodate the filters of the type and style scheduled and specified at maximum filter face velocity of 500 fpm. Filters shall be as scheduled and specified in Section 23 41 13, "Filters and Accessories".
Frame and Support Construction: The filter housing shall be constructed of galvanized steel with support and bracing upstream and down stream to ensure rigid construction.
Filter Racks: Racks shall be provided under this Section for installation on the air handling equipment which it serves. Racks shall be equipped with gaskets and spring type positive sealing fasteners to hold filters in place. Fasteners shall be removable without the use of tools.
- B. Pleated Filters (Prefilter and Final Filters):
 - 1. General: Provide medium efficiency, pleated, disposable type filters where scheduled or shown on the Drawings.
 - 2. UL-listing: Filters shall be listed by Underwriters' Laboratories, Inc. as Class 1.
 - 3. Filter Media: Filter media shall be of the nonwoven cotton fabric type. The filter media shall have an average efficiency of 25% to 30% and an average arrestance of 90% to 92% in accordance with ASHRAE Test Standard 52-76.
 - 4. Capacity: Ratings and capacity for pleated filters shall be as follows:
 - a. Two Inch (30% Efficient Prefilter): The effective filter media shall be not less than 4.6 square feet of media per 1.0 square foot of filter face area and shall contain not less than 15 pleats per linear foot. Initial resistance of 500 fpm approach velocity shall not exceed 0.28" w.g.
 - b. Four Inch (65% efficient Final Filter): The effective filter media shall be not less than 7.0 square feet of media per 1.0 square foot of filter face area and shall contain not less than 11 pleats per linear foot. Initial resistance of 600 fpm approach velocity shall not exceed 0.35" w.g..
 - 5. Media Support Grid: The filter media support shall be a welded wire grid with an effective open area of not less than 96%. The welded wire grid shall be bonded to the filter media to eliminate the possibility of media oscillation and media pull away. The media support grid shall be formed in such a manner that it effects a radial pleat design, allowing total use of filter media.

- 6. **Enclosing Frame:** The filter enclosing frame shall be constructed of a rigid, heavy-duty, high wet-strength beverage board, with diagonal support members bonded to the air entering and air exit side of each pleats, to ensure pleat stability. The inside periphery of the enclosing frame shall be bonded to the filter pack, eliminating the possibility of air bypass.
- 7. **Manufacturers:** Filters shall be American Air Filter AM-AIR 300X, Farr 30-30 or an approved equal.

2.7 DAMPERS:

- A. **General:** Provide dampers capable of being motor operated as required under the applicable temperature control section.
- B. **Construction:** Dampers shall be galvanized steel and mounted as a single assembly locked securely to a galvanized steel rod that rotates on nylon or teflon bushings. Dampers shall be sectionalized to limit blade length to 50" maximum to prevent excessive blade warping. Closed cell neoprene, vinyl polyester or polyurethane blade edging shall be installed to assure tight closure.
- C. **Testing:** A representative 4 square foot damper sample shall not exceed 6ÿcfm leakage/square foot at 4"ÿwg, when tested by an independent testing laboratory in accordance with AMCAÿ500Ä74.
[Inlet [Mixing] Dampers: Provide a [mixing box] [damper] section with [ganged] vertical, low leakage, opposed blade dampers positioned across the short dimension of each [outside] air opening. [Each set of dampers in either air inlet shall be offset with respect to the dampers in the other air inlet to provide high efficiency mixing through generation of relative velocity between the merging narrow air streams at different temperatures.]
- D. **[Face and Bypass Dampers: Provide low leakage coil face and bypass dampers for [heating] [cooling] coils as scheduled.]**

2.8 VAV MODULATION:

- A. **General:** Air handling unit variable air volume (VAV) modulation shall be via solid state variable speed drives as specified in Section 23 04 10, "Electronic Variable Speed Drives".

ACOUSTIC PERFORMANCE:

[edit to suit project]

General: The custom air handling units provided for the project shall be of a low noise design to reduce audible HVAC system noise levels in office areas and similar spaces adjacent to air handling unit rooms.

Criteria: The air handling units shall cause a maximum allowable sound power level (SPL) in dB, measured in a mocked-up office space adjacent to a simulated air handling unit room, which does not exceed NC40. The specific octave band maximum SPL valves shall not exceed the following:

Octave Band	Frequency (Hz)	Allowable SPL (dB)
1	63	64
2	125	56
3	250	50
4	500	45
5	1000	41
6	2000	39
7	4000	38
8	8000	37

- B. **Preliminary Submittal:** Shop Drawing submittals shall include manufacturer's certified mock-up test results from previous mock-up testing to verify the manufacturers ability to meet the specified sound criteria. Tentative approval will be made based upon submitted data, subject to final approval of the mock-up test using two project air handling units.
[FACTORY ACOUSTICAL ACCEPTANCE TESTING:]
[edit to suit project]
[General: Acoustical performance of the project air handling units shall be verified by factory mock-up acoustical testing at the air handling unit manufacturer's facility or designated test

facility. All costs associated with mock-up testing shall be included in the project bid.]
[**Test Method:** A typical project office suite and adjacent air handling unit room shall be mocked-up with a single zone air handling unit, related ductwork, return air provisions, HVAC terminal unit, air devices, and lighting fixtures which will be provided on the project installed. The air handling units and terminal unit shall then be operated at specified capacities and test noise measurements shall be made and plotted on NC curves.]

- C. [**Mock-up Configuration:** The test mock-up shall construct a facsimile of air handling unit room [] and adjacent office suite rooms []. Air handling units [] and [] and HVAC terminal units [] shall be installed with related ductwork and air devices.]
- D. [**Mock-up Area:** The mock-up shall be constructed in a sound isolated area with a background noise level of NC30 or lower.]
[**Air Handling Unit Room:** The mock-up air handling unit room shall be constructed as follows:]
1. [Partitions shall be constructed using staggered 3⁵/₈" metal studs on 24" centers and two layers of 5/8" gypsum board installed with staggered joints on each side. Studs shall be staggered 4" with an acoustical blanket serpentine through the studs, filling the partition air space.]
[The room shape, dimensions, and door location shall conform to the project design. The room shall be 13' high and simulated structure shall be constructed using a minimum of two layers of 3/4" plywood. The air handling unit room partitions shall extend up to the plywood "structure".]
- E. [**Suite Test Rooms:** The mock-up test office suite rooms shall be constructed as follows:]
[Partitions shall be constructed using 3⁵/₈" metal studs on 24" centers. Perimeter partitions shall extend through the ceiling up to the plywood structure. Interior partitions shall terminate at the suspended ceiling.]
[Room shape, dimensions, and door locations shall conform to the project design. The building structure above the office areas shall be simulated by extending the two layers of 3/4" plywood which form the ceiling of the air handling room across the office mock-up area. Provide a 9' suspended ceiling, lighting fixtures and air devices in the mock-up offices per the project design.]
[**Air Handling Units:** Air handling units constructed per the project specifications shall be installed in the mock-up per the project design. Units shall be isolated on nominal 3/4" ribbed neoprene pads.]
[**Ductwork:** Ductwork shall be installed to simulate the project design.]
1. [Single duct trunk ductwork and lined return air ductwork shall be installed per the project drawings and shall extend 30' beyond the mock-up to an open discharge.]
[Opposed blade dampers shall be installed in the supply duct discharge for static pressure simulation.]
 2. [Ductwork to the HVAC terminal units and air devices shall be installed per the project drawings.]
 3. [Return air attenuator and boots shall be installed per the project drawings.]
 4. [Ductwork construction, liner, external insulation and other components shall be as specified for the project.]
 5. [Test Procedure: The mock-up set-up and test Procedure shall be as follows:]
[The ambient noise level in the mock-up test area shall be NC30 or less.]
[The single zone air handling unit shall be balanced to test cfm's and design static pressure. CFM shall be measured by air velocity traverse to the supply duct.]
 6. [The HVAC terminal units and air devices shall be balanced for cfm's shown on the project drawings. The HVAC terminal units shall be operated as a constant volume unit with 60% cold air and 40% plenum air for the duration of the test.]
 7. [The single zone unit static pressure controls specified for the project shall be installed and shall be used to vary supply fan volume during testing.]

8. **[The supply volume for the single unit shall be varied (via the supply air balancing damper) to allow testing at 100%, 90%, 75%, and 50% of design cfm.]**
[Noise measurements shall be taken at 3' above the floor in the center of each of the three test rooms and plotted on NC curves. Curves for tests at each air flow shall clearly indicate all conditions during the test.]

- F. **[Proposed Mock-up: The configuration and construction details and test procedure/reporting forms for the proposed mock-up shall be submitted to the Engineer for approval prior to construction of the mock-up.]**
[Acceptable Test Results: Test results which produce a SPL as specified in Paragraph 2.10 above and lower in each room in the suite test rooms will result in approval of the air handling unit acoustic performance.]

PART 3 - EXECUTION

3.1 AIR HANDLING UNIT INSTALLATION:

- A. General: Install air handling units in accordance with the manufacturer's written recommendations and as detailed on the Drawings.
- B. Housekeeping Pads: Install floor mounted air handling units on reinforced concrete housekeeping pads as specified in Section 23 03 00.
- C. Vibration Isolators: Air handling units shall be installed with vibration isolators as specified under Section 15250, and separated from ductwork with flexible duct connections.
- D. Drain Connections: Pipe condensate **[directly to a primed floor drain without a trap for blow-through units and]** via a P-trap to a primed floor drain **[for draw-through units]**. Provide P-traps on air handling unit condensate drain connections with seal depths at least equal to the total static pressure of the unit as installed. P-traps shall be constructed of pipe and tees as detailed on the Drawings. Elbows shall not be used. All unused openings of tees shall be closed with removable plugs which shall serve as cleanouts.
- E. Coil Pull Space: Air handling units shall be installed with adequate space to allow unit coils to be removed **[without demolition of building construction]**. Coil pull space **[and any required demolition of building construction]** shall be clearly indicated on As-built Drawings. The Contractor shall insure that all field-piping, valves, ductwork, and other obstructions are not in the way or can be easily removed with flanges to facilitate coil removal.
- F. Vents and Drains: Provide **[manual] [automatic]** air vents and drain **[plugs] [valves with hose connections and caps]** for each coil section.

3.2 AIR FILTERS:

- A. General: Unit shall be furnished and installed all filters as required for start-up.
- B. Filters and Accessories: Install filter racks, housings, and filters in accordance with the manufacturers' written installation instruction.
- C. Filter Sizes: In all cases, filters shall be of the proper size and installed in filter racks in such a manner that there will be no leakage of air around filters. Filters which have been torn, distorted, or damaged in any other way will not be acceptable.
- D. Temporary Prefilters: Provide blanket insulation or roll filter media over the pleated prefilters as temporary filter.
- E. Spare Filters: Furnish one complete stock of replacement filters and media, sufficient to replace all filters on each of the unit, to the Owner for maintenance use. Filters shall be delivered in their original, unopened containers, and stored as directed by the Owner.

3.3 TESTING AND BALANCING:

- A. General: Refer to Section 23 05 93 for air handling unit testing and balancing.
- B. Vibration Testing: Provide field vibration testing as specified in Paragraph 2.01/C.

3.4 IDENTIFICATION:

- A. Refer to Section 23 03 00 for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 74 20

SECTION 23 76 13 - PACKAGED AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide field or factory-assembled air handling units and components as shown, scheduled, and indicated on the Drawings.
- B. Types: The types of air handling units required for this project include:

[EDIT TO SUIT PROJECT]

1. Single-zone constant volume indoor air handling units.
2. Single-zone variable air volume indoor air handling units.
3. Multizone indoor air handling units.

1.3 QUALITY ASSURANCE:

- A. Manufacturer: Provide products complying with these specifications and produced by the following:

[EDIT TO SUIT PROJECT]

1. Carrier.
 2. McQuay (part of Daikin Industries).
 3. Thermal.
 4. Trane.
 5. York.
- B. Coil Certification: Coils shall be designed and rated in accordance with ARI Standard 410.
- C. AMCA Seal: Fans shall be designed and rated in accordance with AMCA Standards and shall bear the AMCA Seal.
- D. Vibration Testing: Factory-vibration testing shall be provided as specified in Paragraph 2.01/C.
- E. Pressure Leakage Testing: Coils shall be factory leak tested as specified in Paragraph 2.03/A.
- F. **[Damper Leakage: Multizone dampers shall be factory-certified per AMCA Standard 500-74.]**

1.4 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
1. Certified drawings showing overall dimensions of complete assembly, weights, support requirements, sizes, location of connections, accessories, and parts list.
 2. Cut sheets on all air handling equipment, clearly marked to show sizes, configuration, construction, features, accessories and other pertinent information.
 3. Curves showing fan performance and system operating point plotted on curves. Data to substantiate that fan can operate in a stable range with a static pressure 1/2" above that schedule, and that the fan motor is sized accordingly.
 4. Coil performance selection data showing all criteria identified on equipment schedule. Certify the coils will meet performance criteria on equipment schedules.
 5. **[Complete information on the Variable Air Volume modulation method to be furnished.]**
 6. Required torque for all motor-operated dampers **[and inlet vanes]** information on shaft sizes and location in unit and amount of space available for motor operators.
 7. Performance certifications based on applicable ARI Standards and prototype unit test reports.
 8. Product warranties and guarantees.

9. Wiring diagrams.
10. Written instructions for installation including assembly where not factory-assembled.
11. Motor data as required in Section 23 04 00.
12. Additional information as specified in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver air handling units in factory-fabricated water-resistant wrapping.
- B. Handle air handling units carefully to avoid damage to material components, enclosure, and finish.
- C. Store air handling units in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. Draw-thru Type Air Handling Units: Provide draw-thru type air handling units complete with fan section, **[inlet vanes] [magnetic variable speed drives] (variable air volume units only),** adjustable blower drive for balancing, and fixed drive for permanent installation with motor mounted on resilient base, V-belt drive with guard, air filter section, **[heating coil section,]** cooling coil section, condensate drain pan, and other attached sections indicated on Drawings, specified herein or required to accomplish the specified control sequences.
- B. Blow-thru Type Air Handling Units: Provide blow-thru type air handling units complete with fan section, **[inlet vanes] [magnetic variable speed drives] (variable air volume units only),** adjustable blower drive for balancing, and fixed blower drive for permanent installation with motor mounted on resilient base, V-belt drive with guard, air filter section, cooling coil section, air distribution grid, **[bypass section with equalizing baffles,]** condensate drain pan, **[custom low leakage zone mixing damper section (multizone units only),]** and other attached sections indicated on the Drawings, specified herein or required to accomplish the specified control sequences.
- C. General Construction: Fans, sheaves, motors, and belts shall be factory-assembled and balanced with the fan section casing. Air handling unit fans, bearings, and fan sheave shall be balanced to a maximum of 2 mil in all axes and shall be so certified by the manufacturer prior to installation. The manufacturer shall conduct vibration tests on all units after they have been installed in the field. Vibration shall not exceed 2 mils in all axes and shall be so certified by the manufacturer in writing prior to the Contractor placing the unit in service. Replace all components that cannot meet these balance and vibration requirements.
- D. Capacity: Unit characteristics, size, type, capacity, and arrangement shall be as scheduled and shown on the Drawings. Unit shall be capable of stable operation at a static pressure 1/2" above that scheduled and the fan motor shall be sized accordingly.

2.2 HOUSING:

- A. General: Housing shall be airtight, of sectionalized design with suitable gaskets between sections. Materials shall be phosphatized, bonderized or galvanized steel of lock-forming quality. Steel angle framework shall be designed to provide maximum rigidity, prevent pulsation and shall be of the same finish as the housing. Housing shall include fan section and coil sections with drain pan.
- B. Finish: Galvanized metal shall not be painted. Phosphatized or bonderized metal shall be finished with rust-inhibiting paint.
- C. Coil Section: All connections, coil headers, and return bends shall be completely enclosed. Coil frames shall not be used as reinforcing for the housing. Construction shall be such that the coils can be removed through access panels without affecting the structural integrity of the casing.
- D. Drain Pan: Provide a rigid and watertight drain pan with pipe drain connection under the complete coil section on horizontal units and under the fan and coil section on vertical units. Drain pan shall be of the double pan insulated type with a **[316L stainless (preferred)] [galvanized]** steel inner pan and a galvanized or painted steel outer pan. **[The inner pan shall be coated with corrosion resistant elastomeric material.]** Insulation shall be one inch (1") thick, high density fiberglass cemented and vapor sealed between the inner and outer pan. Foamed in place, closed cell insulation is not allowed.

[An] [A 316L stainless steel] intermediate condensate drip pan shall be provided on all coils over 48" high. Intermediate drain pans shall be factory-piped to main condensate drain pan. Drain pans shall be positively sloped internally to external drain connections as shown on the Drawings.

- E. Access Doors: Provide access doors a minimum of 3/4 of a square foot, but no larger than 6 square feet in size, in the fan and coil sections for inspection and/or access to internal parts. Doors with one dimension 12" or less, shall be equipped with Ventlok Style 100 latch. All other doors shall be equipped with Ventlok Style 140 latch and Ventlok Style 150 hinges. Locate door to allow inspection regardless of mounting arrangement. Door insulation shall be separate from unit insulation and shall be secured and sealed to the door.
- F. Insulation: Housings shall be internally insulated with minimum one inch (1"), 3 pound density Manville "Lina-Coustic", "Exact-O-Mat", "Tuf-Skin", or "Aeroflex 200B". All exposed parts such as angles, braces, and similar items in contact with exterior surfaces shall be covered with insulation to prevent condensation on the exterior casing. Insulation shall be installed to allow panel removal without disturbing insulation. Insulations shall be secured to the casing surfaces and framework with adhesive over entire surface and stick clips, grip nails, or weld pins with fasteners on approximate 24" centers. The insulation shall be protected from delamination or fretting by coating exposed edges with adhesive or mastic. All insulation shall have a composite fire and smoke hazard rating as specified in Section 15200, "System Insulation".

2.3 COILS:

- A. General: Coils shall have capacities and ratings as scheduled and shall be rated by the manufacturers in accordance with ARI Standard 410. Noncertified coils will not be acceptable.
- B. Core Construction: Coils shall be constructed of copper tubes with **[aluminum] [or] [copper]** plate fins with a maximum of **[eight] [twelve]** fins per inch and shall be arranged for counterflow operation. Spiral fins are not allowed. Fins shall be bonded to the tubes by means of mechanical expansion of the tubes **[or by spiral welding under tension]**. Supply and return connections shall be on the same end of the coil. Tubes shall be 1/2" or 5/8" OD spaced approximately 1-1/2" apart, with a minimum wall thickness of **[0.020"] [0.035"]**. Flat fins shall have a minimum wall thickness of 0.0055". Tapered smooth fins shall taper in thickness from 0.01" at point of contact to 0.005" at the periphery.
- C. Headers: Coil headers and connections shall be constructed of heavy wall copper or IPS brass. Joints between core tubing and headers shall be of a recessed swage design to provide a large mating area for brazing. Supply and return connections shall be terminated NPT threaded connections with wrench flats.
- D. Casings: Coil casings shall be constructed with structural angle shapes bolted with stainless steel bolts and rigidly supporting the coil assembly. Casing frame members shall extend over the ends and edges of the coil and shall have formed holes for tubes, permitting free expansion and contraction of coil components. Intermediate tube supports shall be provided such that maximum unsupported tube length does not exceed 48". Casings, including all supports and frames, shall be constructed of **[316L stainless steel] [for all cooling coils] [and preheat coils] [and] [galvanized steel]** for all **[heating]** coils.
- E. Miscellaneous Requirements:
 - 1. Coils installed in series shall have a minimum of **[12"] [_____"]** between the faces with provisions for access between the faces for cleaning.
 - 2. Provide drain and air vent connections, except where the coil header piping is designed to be self-venting.
 - 3. Test coils by air pressure under water at 1-1/2 times the pressure classification indicated on the Plans. The test pressure shall in no case be less than 250 psig, nor more than 500 psig.
- F. Chilled Water Cooling Coils: Coils shall be a minimum of **[six] [eight]** rows deep. Cooling coil capacity, maximum face velocity, and maximum air pressure drop shall be as scheduled. Water velocity in the tubes shall not exceed 5' per second and the water pressure drop through the coil shall not exceed **[10'] [20']**, unless lower maximums are scheduled. All cooling coils shall be installed in a vertical position (perpendicular to airflow) to minimize condensate carry over. Coils shall be designed

and certified by the manufacturer to operate at the scheduled face velocity plus 10% without moisture carry over.

- G. Hot Water Heating Coils: Coils shall be furnished in the unit where scheduled and shall have a minimum of two rows. Heating coil capacity, maximum face velocity and maximum air pressure drop shall be as scheduled. Coils shall be installed in the bypass or heat position, except in outside air units where the coils shall be in the preheat position. Water velocity in the tubes shall not exceed 5'per second and water pressure drop shall not exceed 10', unless lower maximums are scheduled.

2.4 MOTORS:

- A. General: Motors shall be open dripproof (ODP), 3-phase, 1750 rpm, unless noted or scheduled otherwise. All motors shall be high efficiency, energy efficient type. Motor selection shall be such that the motor will not overload if the static pressure drops 1/2" below or rises to 1/2" above the specified value. Motors shall be mounted on the coil connection side, unless indicated otherwise and the motor shall be mounted on an adjustable base rigidly supported to the unit. The motor shaft shall accommodate an adjustable pitch motor sheave. Refer to Section 15140 for additional motor requirements.

2.5 FANS AND DRIVES:

- A. Centrifugal Fans: Provide double width, double inlet, multiblade type fans with air foil, forward curved or backward inclined blades, as scheduled. All fans shall be statically and dynamically balanced and tested after being installed on properly sized shafts. Fan shafts must not pass through their first critical speed as unit comes up to rated rpm. Fan wheels and scrolls shall be constructed of galvanized steel, all aluminum or fabricated steel protected with two coats of rust-inhibiting paint. Wheels and scrolls of fans used for outside air service shall be coated with two coats of fire resistant epoxy paint.
- B. Drives: Select drives for a minimum belt horsepower capacity of 150% of the motor nameplate horsepower. Provide selection calculations with the drive submittal. The selection calculations shall include the correction factor for arc of contact.
- C. Sheaves: Permanent fan sheaves shall be nonadjustable with removable machined bushings, machined on all contact surfaces. Sheaves with over three grooves shall be dynamically balanced and so designated on each sheave. Fan sheaves with three grooves or less shall be statically balanced and if weights are required, they shall be welded to the sheave. Sheaves shall be manufactured by Browning, Eaton Yale and Towne, Dodge Manufacturing Company or Fort Worth Steel and Machinery Company.
 - 1. Typical Floor Air Handling Unit: Provide a nonadjustable type sheave selected for the rated fan rpm as determined. Provide variable sheaves as required to determine correct fan rpm as established by tenant requirements. Furnish additional fixed sheaves as required after correct speed has been determined. All unused fixed sheaves shall become the property of the Owner.
 - 2. Nontypical Air Handling Unit: Provide Browning Type LVP, MVP, or approved equal, adjustable-type with double locking feature. Motor sheave shall be selected for the fan rpm determined by the fan capacity scheduled and shall be adjustable to as close as 10% above and below the rated fan speed. Furnish and install fixed sheaves on units that require more than two belts, after correct speed has been determined with the variable sheave.
- D. Belts: Provide "V-groove" type suitable for the service intended with the capacities specified. Belts shall be closely matched and tagged for use prior to shipment. Recheck belts for proper match during operation and if necessary, replace with closely matched belt sets. Belts shall be Gates, Durkee-Atwood, Goodyear, Uniroyal or Browning.
- E. Shafts: Provide one piece design shafts, either solid or hollow tube with solid stub. Hollow tube with solid stub shafts shall be hot-formed, stress relieved, and manufactured by Pittsburgh Tubular Shafting, Inc. Fans and shafts shall not pass through their first critical speed as the unit comes up to rated rpm.
- F. Shaft Bearings: Provide externally or internally mounted grease lubricated, self-aligning ball or roller bearings on each end of the shaft. Bearings shall have an average B-10 life as defined by AFBMA of **[100,000] [200,000] [_____]** hours at design operating conditions. All bearings shall be the same size. Internally mounted bearings shall have grease lines extended so as to be readily

accessible from the drive side of the unit. In addition, the bearing on the drive end of the shaft shall have grease line extended beyond the belt guard. All grease lines shall terminate in a zerk fitting. Bearings shall be by SKF, Sealmaster, Timken, or Fafnir.

2.6 BELT GUARDS:

- A. **General:** Provide belt guards for all fan drives mounted outside the unit housing. The finish of the guard shall be similar to that of the unit housing. Brace and fasten guards to prevent objectionable vibration. Provide tachometer openings at least 2" in diameter for checking fan and motor speeds. Openings shall be centered on shafts to allow checking rpm.

2.7 FILTERS:

- A. **General:** Provide, as a part of the factory package, filter sections to accommodate the filters of the type and style scheduled and specified at maximum filter face velocity of 500 fpm. Filters shall be as scheduled and specified in Section 23 41 13, "Filters and Accessories".

3.1 DAMPERS:

- A. **General:** Provide dampers capable of being motor operated as required under the applicable temperature control section.
- B. **Construction:** Dampers shall be galvanized steel and mounted as a single assembly locked securely to a galvanized steel rod that rotates on nylon or teflon bushings. Dampers shall be sectionalized to limit blade length to 50" maximum to prevent excessive blade warping. Closed cell neoprene, vinyl polyester or polyurethane blade edging shall be installed to assure tight closure.
- C. **Multiple Zone Dampers:**
1. **General:** Provide low leakage zone dampers with aluminum or galvanized steel blades, galvanized steel or brass shafts, brass or teflon end bearings, and galvanized steel or aluminum frames. Blades shall be a maximum of 8" wide.
 2. **Leakage:** Leakage rate for dampers and damper section shall not exceed **[10 cfm] [_____ cfm]** per square foot of damper face area at 3" WG static pressure, with a maximum closing torque of 4 inch-pound/square foot of damper face area. Certified AMCA laboratory test data in accordance with AMCA Test 500, shall be submitted to Engineer for review.
 3. **Linkage:** Provide factory-customized linkage, factory-mounted and adjusted, with one operator rod per zone extended for field-connection of a motor operator.
 4. **Submittals:** Damper construction, linkage hardware, zoning arrangements, and provisions for motor operation connections shall be submitted for review.
- D. **Inlet Mixing Dampers:** Provide a mixing box section with ganged vertical, low leakage, opposed blade dampers positioned across the short dimension of each air opening. Each set of dampers in either air inlet shall be offset with respect to the dampers in the other air inlet to provide high efficiency mixing through generation of relative velocity between the merging narrow air streams at different temperatures.
- E. **Face and Bypass Dampers:** Provide low leakage coil face and bypass dampers for **[heating] [cooling]** coils as scheduled.

2.8 [VAV MODULATION:]

[EDIT TO SUIT PROJECT]

- A. **[General:** Air handling unit variable air volume (VAV) modulation shall be via **[solid state variable speed drives as specified in Section 23 04 10, "Electronic Variable Speed Drives",] [magnetic variable speed drives (*preferred*)] [[variable fan inlet vanes] mechanical variable speed drives] [pneumatically controlled dampers].]**
- B. **[Inlet Vanes:** Provide controllable steel inlet vanes in the inlet of variable air volume fans to vary air volume from full volume to full shut-off. The inlet vane edges shall be form fit to the fan inlet cone circumference. Inlet vanes shall be operated from a center or perimeter controlling mechanism with **[machined bronze] [roller] bearings through a control linkage suitable for motor operation.]**

[OR]

- C. **[Magnetic Variable Speed Drive (VSD):** Provide Magna-Speed IKV series or approved equal magnetically controlled VSD's for fan speed modulation. Drive shall consist of a fan-armature assembly mounted directly on the motor shaft and a V-belt sheave assembly on support bearings. Application of dc voltage via slip rings to the armature coil shall magnetically couple the two components causing the V-belt sheave assembly to rotate at a speed which varies with the applied dc voltage and resultant magnetic field strength. A "frequency" signal proportional to the speed of the V-belt sheave assembly shall provide feedback to the drive controller for speed control.]
- D. **[Drive Controller:** The magnetic VSD controller shall be a MPS, Inc. ED 450-C/ED 900-C series or approved single unit controller containing all components required for operation of the drive in response to an external 4-20 mA analog control signal. The controller shall include, but not be limited to, the following features and options:
1. NEMA 12 enclosure with labeled manual/off/auto selector switch, manual speed control potentiometer and digital speed display on the cover.
 2. 120 volt, ac input, 45 or 90 volt dc output power supply, as required.
 3. Status monitor LED's for controller setup.
 4. Speed meter drive card.
 5. [4-20 mA current] [pneumatic] input follower card.
 6. Digital frequency (speed) feedback from drive.
 7. Adjustable minimum and maximum speed.
 8. Adjustable torque limit.
 9. Independently adjustable (0-40 seconds) acceleration and deceleration ramp speeds for "soft" start and stop.]
- E. **[Fan Drive Sheave:** Fan drive sheave shall be selected to allow fan operation at 110% of design fan speed with magnetic VSD operating at 100% drive speed.]

[OR]

- F. **[Mechanical Variable-Speed Drives:** shall be a factory-installed variable-speed drive system which is capable of fan speed reduction to approximately 40% of design rpm. Drive design shall provide a service factor of 1.4. The drive assembly shall consist of a fan motor mounted on a movable base, a spring loaded variable pitch drive pulley, two fixed-pitched jackshaft pulleys and a fixed pitch fan shaft pulley. The jack-shaft shall be solid steel and shall be supported by regreasable pillow block bearing, selected for an average life of 200,000 hours at design condition. All drive belts shall be factory-furnished. The movable motor base shall be fitted with permanently lubricated bronze bearing which shall ride on polished chrome rails. The motor base shall be chain driven by a 1/10 hp reversing type gear motor. Control shall be via a factory-furnished, field mounted electric control panel. The panel shall contain control relays, a manual fan speed switch, a fan starter auxiliary contact, a mode switch, control transformer, gear motor start capacitor and terminal block. The control shall be activated by a duct mounted pneumatic static pressure sensor furnished under Section 23 06 00, "Building Control and Automation (BCAS)". Mechanical variable-speed drives shall be Carrier Modudrive, McQuay (part of Daikin Industries) Max-E-Drive or an approved equal.]

[OR]

- G. **[Pneumatic Dump Dampers:** Dampers and controls shall be as specified in Section [_____, "_____."]]

PART 3 - EXECUTION

3.1 AIR HANDLING UNIT INSTALLATION:

- A. **[General:** Install air handling units in accordance with the manufacturer's written recommendations and as detailed on the Drawings.

- B. Housekeeping Pads: Install floor mounted air handling units on reinforced concrete housekeeping pads as specified in Section 23 03 00.
 - C. Vibration Isolators: Air handling units shall be installed with vibration isolators as specified under Section 23 05 48, and separated from ductwork with flexible duct connections.
 - D. Drain Connections: Pipe condensate **[directly to a primed floor drain via a P-trap for blow-through units and]** via a P-trap to a primed floor drain **[for draw-through units]**. Provide P-traps on air handling unit condensate drain connections with seal depths at least equal to the total static pressure of the unit as installed. P-traps shall be constructed of pipe and tees as detailed on the Drawings. Elbows shall not be used. All unused openings of tees shall be closed with removable plugs which shall serve as cleanouts.
 - E. Coil Pull Space: Air handling units shall be installed with adequate space to allow unit coils to be removed **[without demolition of building construction]**. Coil pull space **[and any required demolition of building construction]** shall be clearly indicated on As-built Drawings. The Contractor shall insure that all field-piping, valves, ductwork, and other obstructions are not in the way or can be easily removed with flanges to facilitate coil removal.
 - F. Vents and Drains: Provide **[manual] [automatic]** air vents and drain **[plugs] [valves with hose connections and caps]** for each coil section.
- 3.2 AIR FILTERS:
- A. General: Unit shall be furnished and installed all filters as required for start-up.
 - B. Filters and Accessories: Install filter racks, housings, and filters in accordance with the manufacturers' written installation instruction.
 - C. Filter Sizes: In all cases, filters shall be of the proper size and installed in filter racks in such a manner that there will be no leakage of air around filters. Filters which have been torn, distorted, or damaged in any other way will not be acceptable.
 - D. Temporary Prefilters: Provide blanket insulation or roll filter media over the pleated prefilters as temporary filter.
 - E. Spare Filters: Furnish one complete stock of replacement filters and media, sufficient to replace all filters on each of the unit, to the Owner for maintenance use. Filters shall be delivered in their original, unopened containers, and stored as directed by the Owner.
- 3.3 TESTING AND BALANCING:
- A. General: Refer to Section 23 05 93 for air handling unit testing and balancing.
 - B. Vibration Testing: Provide field vibration testing as specified in Paragraph 2.01/C.
- 3.4 IDENTIFICATION:
- A. Refer to Section 23 03 00 for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 76 13

SECTION 23 81 23 - COMPUTER ROOM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide computer room air conditioning unit work including, but not limited to, the furnishing and installation of complete, self-contained, factory-assembled, computer room air conditioning systems. Design the system for **[draw] [blow]** through air arrangement with **[downflow] [top]** delivery to ensure even air distribution across the face of the coil. System shall be completely prepped, prewired, and ready for final connection.
- B. Types: The types of computer room air conditioning units required for this project include, but are not limited to, the following:
 - 1. Chilled water/electric heat units.
 - 2. Chilled water/hot water units.
 - 3. Glycol/electric heat units.
 - 4. Chilled water with DX backup/electric heat units.
 - 5. Air cooled/electric heat units.

1.3 QUALITY ASSURANCE:

- A. Manufacturer: Provide products complying with these specifications and produced by one of the following:
 - 1. Liebert Corporation. [UH Standard]
 - 2. **[Airflow.]**
 - 3. **[Stultz.]**

1.4 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 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver computer room air conditioning units and accessories in factory-fabricated water-resistant wrapping.
- B. Handle computer room air conditioning units and accessories carefully to avoid damage to material components, enclosure and finish.
- C. Store computer room air conditioning units and accessories in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. General: Except as otherwise indicated, provide materials and components as indicated by manufacturer's product information and as required for a complete installation. Computer room air conditioning units shall utilize **[building chilled water and a chilled water cooling coil] [a glycol-**

cooled DX cooling system] [an air-cooled DX cooling system] as the primary cooling and dehumidification source. [When direct chilled water cooling is not adequate to provide the required temperature and humidity control, the unit controls shall automatically activate the DX cooling system to provide the required cooling and dehumidification while rejecting heat to the building chilled water system.]

- B. Unit Capacities: Unit capacities shall be as scheduled or shown on the Drawings.
- C. Cabinet and Frame Construction: Unit frames shall be constructed of welded tubular steel. Interior sheet metal panels shall be welded to the frame assembly and the exterior panels shall be insulated with a minimum one inch, 1-1/2 pcf fiber insulation. All panels shall have concealed fasteners and be easily removed to provide access to equipment. Panels shall be arranged so as to provide access to electrical control panel and control valve compartment without interrupting air flow. The main unit color shall be IBM-white and the accent panel shall be **[IBM-blue]**.

[SELECT ONE OF THE FOLLOWING]

- D. A-frame DX Cooling Coil: Cooling coil shall be of an A-frame design with four rows and a maximum face velocity of 550 fpm. Construction shall be of copper tubing mechanically expanded into aluminum plate fins. The refrigerant circuits shall be designed to distribute refrigerant into the entire coil face area. Entire coil assembly shall be mounted in a stainless steel condensate drain pan.]

[OR]

- E. A-frame Chilled Water Cooling Coil: Cooling coil shall be of an A-frame design with six rows and a maximum face velocity of 500 fpm. Construction shall be of copper tubing mechanically expanded into aluminum plate fins. The chilled water circuits shall be designed to distribute water into the entire coil face area. Entire coil assembly shall be mounted in a stainless steel condensate drain pan.]

[VERIFY IF REQUIRED]

- F. Chilled Water Cooling Coil: Cooling coil shall be a custom-designed six-row chilled water cooling coil with copper tubes and aluminum fins. The coil shall be installed in the return air portion of the unit and shall provide full cooling capacity with 45°F entering chilled water. Coil shall be tested at 300 psi air under water.

[SELECT ONE OF THE FOLLOWING]

- G. Electric Reheat: The units shall be furnished with electric reheat coils. Coils shall be low wattage density, fin tubular, stainless steel construction and shall be protected by thermal safety switches. Three stage reheat control shall be provided for CRAC Units [_____, _____] and [_____] and two stage reheat control shall be provided for CRAC Unit [_____, _____] and [_____]. Each stage of heating shall be 3-phase.]

[OR]

- H. Hot Water Reheat: Heating coil shall have copper tubes and aluminum fins. Coil shall be tested at 300 psi air under water.]

[VERIFY IF I, J AND K ARE REQUIRED]

- I. Refrigeration System: [CRAC Units [_____, _____] and [_____]] shall employ two redundant and completely separate refrigerant circuits. [CRAC Units [_____, _____] and [_____]] shall employ a single refrigerant circuit. Each refrigeration circuit shall include hot gas mufflers, liquid line filter dryers, refrigerant sight glass with moisture indicator; adjustable, externally equalized expansion valves, and liquid line solenoid valves. All refrigerant piping shall be Type "L" copper tubing.
- J. Compressors: The compressors shall be located in a separate compartment so that they may be serviced during operation of the equipment. [CRAC Units [_____, _____] and [_____]] compressors shall be a semi-hermetic design with a suction gas-cooled motor, vibration isolators, thermal overloads, oil sight glass, manual reset high pressure switch, pump down

low pressure switch, suction line strainer, reversible oil pumps for forced feed lubrication, and a maximum operating speed of 1750 rpm. Compressors shall have a minimum EER of 11.4 based on ARI standard conditions. Compressors shall have cylinder unloaders controlled via the unit microprocessor to provide energy efficient operation at reduced loads. **[CRAC Units [_____, _____] and [_____]]** compressor shall be a hermetic design with high and low pressure safety switches, externally equalized expansion valve and a refrigerant sight glass/moisture indicator. Compressors shall be warranted 5 years.

- K. Four-step Compressor Control: **[CRAC Units [_____, _____] and [_____]]** control systems shall include cylinder unloaders on the semi-hermetic compressors. The unloaders shall be activated by solenoid unloaders controlled by the control system microprocessor. In response to the return air temperature, the control system shall operate the unloader and liquid line solenoids to provide four stages of cooling. The stages shall be 1) one compressor unloaded, 2) two compressors unloaded, 3) one compressor unloaded and one compressor loaded, and 4) two compressors loaded. On a call for dehumidification, the control system shall cause at least one compressor to fully load for dehumidification.
- L. Air-Cooled Condensers: Each unit shall be provided with a low profile, slow speed, multiple direct drive propeller fan cooled, dual circuit air cooled refrigerant condenser. Condensers shall be aluminum construction with copper tube, aluminum fin coils and shall be arranged for **[vertical] [horizontal]** condenser air discharge. Condensers shall be sized to balance the heat rejection of each compressor when supplied with **[105°F] [115°F] [_____ °F]** inlet air.

[OR]

- M. **[Glycol-cooled] [Chilled Water-cooled]** Condensers: Each refrigerant circuit shall be provided with a separate, cleanable, shell and tube counterflow-type condenser heat exchanger with removable heads. Condenser heat exchangers shall be ASME-stamped for a maximum refrigerant pressure of 400 psi at 300°F and a maximum water pressure of **[150 psi] [300 psi]** at 150°F. Unit **[glycol] [chilled water]** flow shall not exceed **[55 gpm] [_____ gpm]** and maximum pressure drop shall not exceed **[18'] [_____']** of water column.

[SELECT ONE OF THE FOLLOWING]

- N. [Air-Cooled Condenser Control]: Each air-cooled condenser shall be provided with a variable speed fan control system to allow positive computer room air conditioning unit startup and operation at ambient temperatures down to **[-20°]**. Controls shall be completely factory wired and shall sense the highest head pressure of either operating compressor and shall cycle fans and vary fan speed to properly maintain compressor head pressure.]

[OR]

- O. [Glycol-regulating] [Chilled Water Regulating] Valves: Each condenser heat exchanger shall be pre-piped with a 2-way head pressure activated control valve and a parallel bypass valve, each rated at **[150 psi] [300 psi].]**

[OR]

- P. [Chilled Water [and Hot Water] Control Valves]: Each chilled water [and hot water] coil shall be pre-piped with a **[2-way] [3-way]** modulating control valve, rated at **150 psi.**
- Q. Electronic Control System:

[VERIFY CONTROL SYSTEM FEATURES/REQUIREMENTS]

1. Each unit control system shall be microprocessor-based and allow programming of temperature and humidity setpoints, alarm parameters, provide monitoring of operational status and maintain a data base of room conditions and environmental system operational status.
2. The control system shall allow programming of the following room conditions:
 - a. Temperature Setpoint (65°F - 85°F).
 - b. Temperature Sensitivity 1°F - 5°F in 0.1°F increments).
 - c. Humidity Setpoint 40% - 60% RH.

- d. Humidity Sensitivity 1% - 10% RH in 0.1% increments.
3. All setpoints shall be adjustable from the individual unit front monitor panel or a hand-held service terminal.
4. Temperature and humidity sensors shall be capable of being calibrated using the front monitor panel controls to coordinate with other temperature and humidity sensors in the room.
5. The **[CRAC Units [_____, _____] and [_____]]** control systems shall also be capable of predictive control of temperature and humidity.
 - a. Temperature Anticipation: The microprocessor shall have the capability of responding the varying rates of temperature change in the computer room. The control system shall delay heating or cooling in response to very low rates of change and shall advance heating or cooling in response to rapid temperature changes.
 - b. Predictive Humidity Control: The microprocessor shall calculate the moisture content in the room and prevent unnecessary humidification and dehumidification cycles by responding to changes in dewpoint temperature.
6. The **[CRAC Units [_____, _____] and [_____]]** control systems shall provide the following internal controls.
 - a. Compressor Short-cycle Control: The control system shall prevent compressor short-cycling by incrementally expanding the control hysteresis of the compressor stages when compressor cycles approach 10 cycles per hour. Timer-based short-cycle control shall not be used.
 - b. Automatic Compressor Sequencing: The microprocessor shall automatically change the lead/ lag sequence of the compressors after each start to lengthen compressor-on cycles and even compressor wear.
 - c. System Auto/Restart: For start-up after power failure, the system shall provide automatic restart with a programmable (up to 10 minutes) time delay. Programming can be performed either at the unit or from the site monitoring system.
 - d. Sequential Load Activation: During start-up, or after power failure, the microprocessor shall sequence operational loads activation to minimize inrush current. Systems allowing multiple loads to start simultaneously shall not be used.
7. Each unit shall be provided with a monitor panel to display operational status, alarms, and permit calibration and programming of operation parameters. All indicators shall be in language form. Symbols or codes will not be acceptable. The front monitor panel shall be provided with a three digit, 0.43" high, seven segment LED numerical display to indicate temperature, humidity, percent capacity (cooling, heating, humidification, de-humidification, and econ-o-cycle), temperature and humidity setpoints and sensitivities, and humidifier flush rate. Operational status (heating, cooling, humidification and dehumidification) and alarm conditions shall be indicated by colored LEDs.
8. The microprocessor shall activate an audible and visual alarm in event of any of the following conditions.
 - a. High temperature.
 - b. Low temperature.
 - c. High humidity.
 - d. Low humidity.
 - e. High compressor head pressure (compressorized systems only).
 - f. Humidifier problem.
 - g. Loss of air flow.
 - h. Change filters.
 - i. Local alarm (customer assignable).
9. The microprocessor shall also provide four customer accessible local alarms to be indicated on the front panel. They shall be capable of being programmable activation time delays.

- a. Audible Alarm: The audible alarm shall have adjustable volume to match the surrounding ambient sound level.
 - b. Common Alarm: A programmable common alarm shall be provided to interface selected alarms with a remote alarm device.
 - c. Remote Monitoring: **[All alarms shall be communicated to the Site Monitoring System with the following information: date and time of occurrence, unit number and present temperature and humidity.] [A common alarm output contact shall be provided for monitoring by [_____].]**
 - d. Alarms: Two customer alarms shall be programmed and used to monitor **[underfloor moisture alarms and firestat unit shutdown]**. The remaining two alarms shall be for future use.
10. The **[CRAC Units [_____, _____] and [_____]]** microprocessors shall provide the capability of maintaining a log of system performance and environmental conditions. This data shall be communicated and displayed at the Site Monitoring System. The following information shall be included in the log, complete with time and date:
 - a. Temperature (present, minimum and maximum for last 24 hours).
 - b. Humidity (present, minimum and maximum for last 24 hours).
 - c. Compressor operating hours.
 - d. Alarm occurrence.
 11. All electronic circuitry shall be provided with self-diagnostics to aid in troubleshooting. Each printed circuit board shall be diagnosed and reported as pass/not pass.
 12. The unit control module shall incorporate a RS-422 communications port for communications with the site monitoring system. No field-modification or programming shall be required for connection to the site monitoring system.

[SELECT ONE OF THE FOLLOWING]

- R. **[Glycol System Control: Each computer room air conditioning unit shall include a dry contact output interface to start the glycol system whenever the unit is operating.]**

[OR]

- S. **[Chilled Water Flow Switch: A factory-mounted and wired flow switch shall activate the unit alarm system upon loss of chilled water supply.]**
- T. Filter Chambers: Unit filter chambers shall be an integral part of the system, designed within the frame and cabinet. The filters shall be rated not less than [60%] [_____%] efficiency by the NBS Atmospheric Dust Spot Test. The filters shall be serviceable from either end of the unit without the use of ladders or special rigging.
- U. Fan Section: Unit fans shall be centrifugal-type, double width, double inlet, and shall be statically and dynamically balanced at the factory as a completed assembly to a maximum vibration level of 2 mils in any plane. Wheels shall be supported on a heavy-duty steel shaft having self-aligning ball bearings with a minimum life span of 100,000 hours. Wheels shall be driven by a [high efficiency, energy efficient type] 1750 rpm fan motor mounted on an adjustable slide base. Refer to Section 15140 for additional motor requirements. The drive package shall be 2-belt, variable speed, sized for 200% of fan motor horsepower. Fans shall be located to draw air over the A-frame coil to ensure even air distribution and optimum coil performance.
- V. Humidifier: Unit humidifiers shall be of the infrared-type consisting of high intensity quartz lamps mounted above and out of the water supply or the self-contained steam generating type with replaceable steam cylinder and shall have a capacity of 22.1 pounds per hour. The evaporator pan shall be stainless steel and arranged to be serviceable for cleaning without disconnecting water supply lines, drain lines, or electrical connections. The complete humidifier section shall include liquid level control and emergency overflow, and shall be prepiped ready for final connection. The primary water supply for the humidifiers shall be distilled condensate water from the cooling coil to ensure that minimum deposits accumulate in the infrared humidifier pan, minimum make-up water is consumed

and to maximize the time between cleaning cycles. The infrared humidification system shall use bypass air to prevent over-humidification of the computer room. The infrared humidifier shall be provided with an automatic flush control system. The flush control system shall be field-adjustable to change the cycle time in accordance with local water conditions. The flush system shall ensure that the primary distilled water supply to the infrared humidifier be from the condensate drain pan and virtually eliminate cleaning maintenance.

- W. Disconnect Switch (Nonlocking Type): Units shall include a non-automatic molded case circuit breaker mounted in the high voltage section of the electrical panel. The complete switch shall include an operating mechanism which is operated from the outside of the unit when the cover for the electrical panel is closed. The operating mechanism shall prevent access to the high voltage electrical components until switched to the "OFF" position.
- X. Floor Stand: Each unit shall be furnished with an adjustable floor stand. The floor stand shall isolate the air conditioning unit from the raised floor and shall be constructed of a welded tubular steel frame with corner gussets. The floor stand shall have adjustable legs connected to vibration isolation pads. The floor stand shall be used to install the air conditioning equipment before the raised floor is put into place to allow all piping and wiring from the unit to be completed before the raised floor is installed. The height shall correspond to the level of the raised floor and have provision for raising the unit one inch and lowering the unit one inch from the raised floor level. A factory-mounted turning vane shall be provided on each stand. The turning vane location shall be coordinated with piping routed under the unit, as detailed on the Drawings.]
- Y. Automatic Restart: Provide each unit with integral automatic restart. The unit shall restart automatically if the unit is stopped due to interruption in power supply. Manual restart is required if unit is stopped by the smoke detector or other safety device.
- Z. Water Detection Tape: Each unit shall be provided with water detection tape which shall be installed under the raised floor where shown on the Drawings to detect the presence of water. Tape length shall be as required to provide detection as shown on the Drawings. The detection tape shall be field-connected to the alarm panel in each unit which shall provide a red indicator and audible alarm. The water detection system shall be an integral part of the unit alarm system which shall display "WATER UNDER FLOOR", when the detection tape is activated.
- AA. Factory Piping and Wiring: Each unit shall be fully factory-piped, wired, and tested such that the only field connections required are for:
1. **[Glycol] [Chilled water] [Refrigerant] [and hot water]** supply and return.
 2. Humidifier cold water make-up.
 3. Condensate drain.
 4. Unit power wiring.
 5. **[External site monitor wiring.]**
 6. **[External EPO system wiring.]**
 7. **[Water detection tape wiring.]**
 8. **[Glycol system control interface wiring.]**
- BB. Firestat: Each unit shall be provided with a factory-installed and wired firestat which senses the return air path and shuts down the unit and activates the alarm system upon sensing excessive heat.
- CC. Turning Vanes: A radius elbow turning vane shall be installed below the raised floor at the unit discharge to direct airflow in the direction noted on the Drawings. The turning vane shall be designed so as to not interfere with the raised floor system.
- DD. Temperature/Humidity Recorders: Provide 7 day/24 hour temperature/humidity recorders of the full scope, two pen type, where shown on the Mechanical and Electrical Drawings. Recorders shall be 110 volts, single phase and shall be supplied with 100 spare charts and red and blue ink supplies.
- EE. Factory Testing: Each unit shall be fully tested at the factory to verify proper operation. All **[refrigerant] [and] [water]** piping and coils shall be fully leak-tested using the manufacturer's standard test procedure.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install each computer room air conditioning 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. Floor Mounting: Units shall be mounted **[on floor stands. Coordinate floor stand installation with raised floor installation.] [directly on the raised floor system. A felt or elastomeric seal shall be provided between the units and the raised floor to provide an air seal. Coordinate required floor panel cutouts for unit connections and air discharge with the General Contractor. Floor system stringers shall not be modified, cut, or removed.]**
- C. Turning Vanes: Install turning vanes below all units mounted on the room perimeter. Vanes shall be installed below the raised floor and shall be notched to fit around the floor system stringers.
- D. **[Refrigerant Piping: Install, test, evacuate and charge refrigerant piping per the manufacturer's recommendations and as specified in Section 23 20 00.]**
- E. Start-up: Unit checkout, start-up, adjustment, and control calibration shall be provided by factorytrained technicians in the direct employ of the equipment manufacturer or the manufacturer's local representative. Start-up and unit checkout schedule shall be coordinated with UH representative and unit operation demonstrated to Owner's representative.
- F. Identification: Refer to Section 23 03 00 for applicable nameplate and labeling requirements. **[Nameplates shall be installed inside the unit cover and the unit manufacturers labeling system shall be used for exposed labeling of units.]**

END OF SECTION 23 81 23

SECTION 23 82 16 - HVAC COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide duct-mounted HVAC [**chilled and**] heating hot water coils as scheduled, specified, and required for the project.

1.3 QUALITY ASSURANCE:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
 1. Aerofin Corporation.
 2. Carrier Machinery and Systems Division.
 3. McQuay (part of Daikin Industries).
 4. Trane Company.
 5. York Division, Borg-Warner Corporation.
- B. ARI Compliance: Comply with Air Conditioning and Refrigeration Institute (ARI) Standard ARI 410 "Standard for Forced-Circulation Air-Cooling and Air-Heating Coils".
- C. SMACNA Compliance: Comply with Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA) standards.
- D. Industry Standards: Comply with American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) recommendations pertaining to HVAC coils, except as otherwise indicated.

1.4 SUBMITTALS:

- A. Submittals: Shop drawing submittals shall include, but not be limited to , the following:
 1. Cut sheets on hot water [**and chilled water**] coils, clearly marked to show coil sizes, construction, features, and other pertinent information.
 2. Coil selections clearly indicating coil sizes, capacities, flows and pressure drops.
 3. Manufacturer's recommended installation instructions.
 4. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver coils in factory-fabricated water-resistant wrapping.
- B. Handle coils carefully to avoid damage to tubes, fins, and casing.
- C. Store coils in a clean, dry space, and protect from weather.

PART 2 - PRODUCTS

2.1 WATER COILS:

- A. General: Provide duct mounted hot water heating and chilled water cooling coils of the type, size and capacity scheduled and shown the Drawings.
- B. Tubes: Tubes shall be round seamless 5/8" OD (less than 60" tube length) or one inch (1") OD (greater than 60" tube length) copper tubes expanded into full fin collars for permanent fin-tube bond and expanded into cast iron headers for permanent leaktight joint. Tubes shall have minimum [**0.020"**] [**0.035"**] wall thickness. Tube supports shall be provided such that the maximum unsupported tube span does not exceed 40".
- C. Fins: Shall be configured, plate-type aluminum **or copper fins** with full fin collars for maximum fin-tube contact and accurate spacing, mechanically bonded to tubes for permanent fin-tube bond.

- D. Casings: Shall be minimum 16 gauge galvanized steel[, **stainless steel for cooling coils**] suitable for duct installation. Duct connection flanges shall be provided. **[Chilled water coil casings shall incorporate an insulated condensate drain pan with main and auxiliary drain connection.]**
- E. Headers: Shall be gray cast iron, fabricated steel, **brass or copper** and shall be located outside of the coil casing to allow uniform air flow across the entire coil surface.
- F. Selections: Coils shall be suitable for maximum working pressures of 225 psi and maximum working temperatures of 325°F. Coils shall have a maximum of 12 fins per inch and a maximum face velocity of **[500 fpm for chilled water coils and]** 700 fpm for hot water coils. Coil air and water pressure drops shall not exceed scheduled maximums. Coil sizes shall be coordinated with ductwork sheet metal sizes to reduce ductwork transitions at coils.
- G. Accessories: Coils shall be provided with drain **[valves with caps] [plugs]** and **[automatic] [manual]** air vents.
- H. Testing: Coils shall be factory tested at **[225 psi] [350 psi]** air pressure under water and suitable for use at working pressures up to **[150 psi] [250 psi]**.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install coil products in accordance with the manufacturer's written instructions, the applicable portions of SMACNA and recognized industry practices, to ensure that products serve the intended functions.
- B. Transitions: Where coil size is different from duct size, duct shall be transitioned to the coil size and then transitioned back in accordance with SMACNA Standards.
- C. **[Drain Pans: Provide an auxiliary drain pan, as specified in Section 23 03 00, under each chilled water coil.]**
- D. Damage: Comb out damaged fins when bent or crushed before enclosing coils in housings.
- E. Cleaning: Clean dust and debris from each HVAC coil as it is installed to ensure its cleanliness.

3.2 FIELD QUALITY CONTROL:

- A. Repair: Repair or replace coils as required, following purging and tightness testing of coils and piping, to eliminate leaks. Replace coils with heavily damaged fins. Retest as specified to demonstrate leakproof performance.

3.3 INSULATION:

- A. General: Non-factory insulated casing, headers, U-tubes shall be insulated as specified in Section 15200.

3.4 IDENTIFICATION:

- A. Refer to Section 23 03 00, for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 82 16

SECTION 23 82 19

FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide fan coil units of the type shown and scheduled on the drawings with accessories as shown, noted or scheduled on the drawings as specified herein.

1.3 QUALITY ASSURANCE:

- A. Manufacturer: Provide products complying with these specifications and produced by one of the following:

1. Carrier Corporation.
2. MagicAire.
3. McQuay (part of Daikin Industries).
4. RECO.
5. Trane Company.
6. Enviro-Tec
7. USA Coil
8. York. York.
9. Williams
10. Krueger

- B. Certification: Provide manufacturer's certification of fan coil unit capacity and compliance with ARI Standard 441.

1.4 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
 1. Cut sheets on all fan coil units, clearly marked to show sizes, configuration, construction, features, accessories and other pertinent information.
 2. Fan curves or tables with selection point clearly indicated.
 3. Motor data as required in Section 23 04 00.
 4. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver fan coil units in factory-fabricated water-resistant wrapping.
- B. Handle fan coil units carefully to avoid damage to material component, enclosure and finish.
- C. Store fan coil units in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. General: Except as otherwise indicated, provide fan coil unit manufacturer's standard materials and components as indicated by his published product information, designed, constructed, and assembled by the manufacturer. Units shall be certified in accordance with ARI 440-84. Unit capacities shall be certified in accordance with ARI Standard 441-66. Unit sound data shall be rated in accordance with ARI Standard 443-70.
- B. Capacity: Heating and cooling capacities and fan characteristics shall be as scheduled or shown on the Drawings and shall be ARI-certified.
- C. Cabinets: Cabinets shall be fabricated of 18 gauge, cold rolled steel or galvanized steel factory-painted, designed to provide a rigid structure for lasting durability and peak performance. Cabinets shall be reinforced for maximum rigidity. Removable panels shall be provided on each side of cabinet for ease of installation and maintenance. The cabinet shall be double wall, insulated both thermally and acoustically with 1" thick insulation. Insulation shall meet NFPA 90A and ASTM E84-70 with flame spread of less than 25 and smoke developed of less than 50 requirements and be UL-listed and labeled.
- D. Water Coils: The coils shall consist of minimum 1/2" OD, 0.020" wall thickness copper tubes, mechanically expanded into aluminum fins. Coils shall have a maximum of 12 fins per inch and coil water and air pressure drops shall not exceed the scheduled maximums. All copper tubes and headers shall be constructed of seamless copper. All water coils shall be furnished with a manual air vent and drain valve. Coils shall be tested at 350 psig air pressure and are suitable for 250 psig working pressure. Hot water coils shall be mounted in preheat position, unless otherwise noted.
- E. Electric Heating Coils: Factory-installed and wired heating coils shall be provided in each unit. Elements shall be 80/20 nickel-chromium wire and shall not glow when in operation. Each element shall be protected by a fusible link and high temperature limit control. Coils shall be complete with magnetic staging contactors and all other required controls factory installed. Coils up to 3 kW shall be single-stage. Coils 3.5 kW and larger shall be two-stage.
- F. Drain Pans: All drain pans shall be fabricated of rugged 304 or 316 SS construction, and insulated with a closed cell polyurethane or polyisocyanurate that is sprayed on and into every crevice of the drain pans. Drain pan shall have an integral auxiliary drain pan connection located above primary drain connection to provide an auxiliary drain. Insulation shall be Underwriters' Laboratories, Inc. listed and labeled. Drain pans shall be pitched for positive drainage with the fan coil unit installed level. All drain connections shall be piped to drain.
- G. Fan Wheels: Fan wheels shall be mounted on a solid steel shaft with ball bearings, all fan wheels shall be heavy duty, galvanized steel, double inlet, forward-curved blade, centrifugal direct-drive or belt-drive type, as scheduled. The wheels shall be dynamically and statically balanced for smooth, quiet operation and shall be direct driven.
- H. Motors: Motors shall be three speed, high efficiency, single phase, permanent split capacitor ball bearing type motors with thermal overload protection for direct drive fans and high efficiency, open-drip-proof motors for belt drive fans. The manufacturer shall furnish a four position three speed switch (Off, High, Medium and Low) with an auxiliary contact for single phase motors. Switch shall be rated for 5.0 amps (full load) at 277 volts ac and shall be installed on the unit at the factory in an easily accessible location.
- I. Filters: Provide manufacturer's standard throwaway filters of glass fiber, 2" thick as specified within 23 40 00 unless scheduled or shown otherwise on the Drawings.
- J. Factory Finish: Finish shall be bonderized, phosphatized, baked-on primer, and baked-on enamel.
- K. Accessories: Provide units with accessories as scheduled or shown on the Drawings and as required for a complete installation. Typical accessories shall include, but not be limited to: supply, return and

outside air duct connections, supply and return air grilles, filter racks, ceiling access doors, valve packages and similar accessories.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install fan coil units, including components and controls required for operation, in accordance with manufacturer's instructions.
- B. Location: Locate each unit accurately in the position indicated in relation to other work. Position unit with sufficient clearance for normal service and maintenance, including clearance for cabinet removal.
- C. Tolerance: Level fan coil units to the tolerance recommended by the manufacturer.
- D. Damaged Fins: Comb out any damaged fins or replace coil if fins cannot be combed to a like-new condition.
- E. Vibration Isolation: Provide unit vibration isolation as specified in Section 23 05 48.
- F. Drain Pans: Install auxiliary drain pans as specified in Section 23 20 10 under all concealed fan coil units. on the drawings and as indicated in the Sequence of Operation..
- G. Auxiliary Drains: Pipe auxiliary drains on fan coil units [to drain pans on concealed units to an approved location.
- H. Filters: Three sets of filters shall be supplied for each fan coil unit. 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.

3.2 IDENTIFICATION:

- A. Refer to Section 23 03 00 for applicable painting, nameplates, and labeling requirements.

3.3 TESTING:

- A. General: Test unit to verify proper operation and correct any defects found.

END OF SECTION 23 82 19

SECTION 23 82 20 - FANS, AIR INTAKES AND RELIEF VENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide supply and exhaust fans, air intakes, and relief vents as scheduled and indicated.
- B. Types: The types of fans, outside intakes and relief vents required for the project include, but are not limited to, the following:
 - 1. Centrifugal roof exhaust fans.
 - 2. Centrifugal upblast roof exhaust fans.
 - 3. Sidewall propeller exhaust fans.
 - 4. In-line exhaust/transfer fans *[may be used for renovation only]*
 - 5. Utility exhaust fans.
 - 6. Upblast smoke exhaust fans.
 - 7. Vane axial supply/exhaust fans.
 - 8. Air intakes.
 - 9. Relief vents.

1.3 QUALITY ASSURANCE:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
 - 1. Acme.
 - 2. Carnes Company, Inc.
 - 3. Cooke.
 - 4. Flakt Products, Inc.
 - 5. Greenheck Fan Corporation.
 - 6. Peerless.
 - 7. Penn Ventilator Company.
 - 8. Trane Company.
 - 9. Woods Fan Division.
- B. AMCA Seals: Provide fans which are rated per AMCA standards and bear the AMCA-certified rating seal.
- C. Electrical Standards: Provide electric motors and products which have been listed and labeled by Underwriters' Laboratories, Inc. (UL) and comply with National Electrical Manufacturer's Association (NEMA) standards.

1.4 SUBMITTALS:

- A. Shop drawing submittals shall include, but not be limited to, the following:
 - 1. Cut sheets clearly indicating fans, air intake and relief vent construction, dimensions, ratings, capacities, and accessories.
 - 2. Cut sheets on roof curbs clearly indicating dimensions, required roof openings, and flashing details.
 - 3. Fan curves with fan selection point clearly indicated.
 - 4. Fan drive selection calculations.

5. Motor data as required in Section 23 04 00, "Motors and Controllers".
6. Additional information as required in Section 23 03 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver fans, intakes, vents, and accessories carefully to avoid damage to material components, enclosure, and finish.
- B. Handle fans, intakes, vents, and accessories carefully to avoid damage to material components, enclosure and finish.
- C. Store fans, intakes, vents, and accessories in a clean, dry space, and protect from the weather.

PART 2 - PRODUCTS

[REFER TO TEXT AFTER END OF SECTION FOR ADDITIONAL FAN TYPES]

2.1 GENERAL FAN REQUIREMENTS:

- A. Ratings: Fans shall be licensed to bear the AMCA-certified ratings seal. Ratings of fans shall be not less than the values shown on the Drawings, based on 69.8°F and 29.92" of Hg atmospheric pressure.
- B. Construction: Fan construction shall be in accordance with AMCA classes of construction for the intended duty. Fan wheels, shafts, and drives shall be statically and dynamically balanced at the factory as a unit. Balancing shall be factory-certified.
- C. Motors: Fan motors shall be 1750 rpm open drip-proof (ODP) or totally-enclosed, fan-coded (TEFC) type as required for the application. Motors 5 hp and larger shall be energy efficient, high efficiency type. Motors shall be selected to be nonoverloading with the fan provided. Refer to Section 15140 for additional motor requirements.
- D. Drives: Provide drives with a minimum belt horsepower capacity of 165% of the motor nameplate horsepower. All fans requiring 1-1/2 hp or larger motor shall include the fan drive selection calculations with the submittal. The selection calculations shall include the correction factor for arc of contact. The submittal data shall identify the source of the selection data.
- E. Motor Sheaves: Motor sheaves shall be Browning Type, MVP, or approved equal, adjustable type with double locking feature. Motor sheaves shall be selected for the rated fan rpm and shall be adjustable to as close as 10% above and below the rated fan speed. Provide fixed sheaves for all motors 3 hp and larger after proper speed has been determined during system balancing.
- F. Fan Sheaves: Provide nonadjustable sheaves with removable machined bushings. Sheaves shall be machined on all surfaces. Sheaves with over three grooves shall be dynamically balanced and the manufacturer shall so designate on each sheave. Fan sheaves with three grooves or less shall be statically balanced and weights required for balancing shall be welded to the sheaves. Manufacturers shall be Browning, Eaton, Yale and Towne, Dodge Manufacturing Company, or Fort Worth Steel and Machinery Company.
- G. Belts: Provide standard "V-groove" belts suitable for the service intended with the required capacities. The belts shall be closely matched and tagged prior to delivery to the job site. If the belts do not appear to be properly matched during operation, they shall be rechecked and, if necessary, replaced. Belts shall be as manufactured by Gates, Durkee-Atwood, Goodyear, Browning, or Uniroyal.
- H. Speed Control: All single phase direct drive fans shall be provided with compatible internally mounted solid state speed controllers, unless noted otherwise.
- I. Bearings: Provide SKF, Sealmaster, Timken or Fafnir, externally or internally-mounted, grease-lubricated, self-aligning ball bearings. Bearings shall have grease type Zerk fittings and shall be selected for a minimum B-10 life as defined by AFBMA of **[200,000]** hours, unless specified otherwise.
- J. Motor Mounts: Motors shall be mounted on an adjustable base rigidly supported on the fan and shall have extended shaft to accommodate the adjustable pitch sheave.

2.2 ROOF CURBS:

- A. General: Provide prefabricated, insulated aluminum roof curbs for all roof mounted fans. Curbs shall be of welded construction and roof-over-flashing type with build-in cant and a minimum overall height of 8" above roof surface, unless otherwise noted or required to meet code requirements. Roof curbs

shall be Greenheck Model #GPS or approved equal for roof decks that are not surface insulated and Model #GPR or approved equal for roof decks that are surface insulated. Damper trays shall be provided to facilitate the mounting of the backdraft dampers, where specified or scheduled. Extended base curbs shall be provided when scheduled or required.

2.3 CENTRIFUGAL ROOF EXHAUST FANS:

- A. General: Provide Greenheck Model G, GB or approved equal ACME, Cook or Carnes centrifugal roof-mounted exhaust fans with capacities as scheduled.
- B. Construction: Fans shall be centrifugal, belt or direct driven as scheduled. Construction of the fan housing, fan wheel and inlet cone shall be aluminum. Wheels shall be aluminum, non-overloading backward curved, centrifugal type and shall be statically and dynamically balanced to assure smooth and vibration-free operation. The entire drive assembly shall be mounted on vibration isolators. Fans shall be constructed to withstand winds up to 150 mph.
- C. Drives: The wheel shaft on belt drive models shall be ground and polished shafting mounted in heavy duty sealed pillow block bearings. Drives shall be sized for a minimum of 165% of driven horsepower. Pulleys shall be fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. An adjustable drive shall be used for balancing and then a fixed drive shall be provided.
- D. Motors: Motor and drives shall be isolated from the exhaust airstream and mounted on vibration isolators. Motors shall be of the heavy duty type with permanently lubricated, sealed ball bearings. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]**
- E. Certification: All fans shall bear the AMCA ratings seals for both air flow and sound performance with birdscreens in place.
- F. **[Coatings: Exhaust fans used for fume hood service shall have all fan parts exposed to the air stream coated with a high temperature acid resistant epoxy coating.]**
- G. Accessories: Provide all required accessories including, but not limited to: aluminum birdscreen, **[gravity (preferred) [motorized] backdraft dampers [with end switch]**, prefabricated insulated aluminum roof curb, factory-mounted and wired **[internal NEMA 1] [external NEMA 3R]** disconnect switch and solid state fan speed controllers (direct drive units only) with a conduit through the roof curb for field wiring.

2.4 CENTRIFUGAL UPBLAST ROOF EXHAUST FANS: (DINING FACILITIES)

- A. General: Provide a Greenheck Model CUBE, CUBE-HP, or approved equal ACME or Cook upblast centrifugal roof-mounted exhaust fans with capacities as scheduled.
- B. Construction: Fans shall be of belt or direct drive as scheduled, upblast vertical discharge type. Construction of housing shall be heavy gauge aluminum. The windband shall have a rolled bead and additional structural members for added strength.
- C. Wheels: The fan and wheel inlet cone shall be non-sparking aluminum and of the high performance, centrifugal blower type. Wheel shall be statically and dynamically balanced. Construction shall include a built in grease drain.
- D. Motors and Drives: Motors and drives shall be isolated from the exhaust air stream and mounted on vibration isolators. Motors shall be of the heavy duty type with permanently lubricated, sealed ball bearings. Air for cooling the motor shall be taken into the motor chamber by means of an air tube from a location free of discharge contaminants. The entire drive assembly and wheel, shall be mounted on vibration isolators as a unit and shall be removable through the support structure without dismantling the fan housing. The wheel shaft shall be mounted in heavy duty ball bearings. Drives shall be sized for 165% of driven horsepower. Pulleys shall be adjustable cast iron type, keyed to the fan and motor shafts. The entire drive assembly shall be mounted on rubber vibration isolators. Motors shall be 1750 rpm open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]**
- E. Certification: All fans shall bear the AMCA Certified Ratings seal for both air and sound performance.
- F. Accessories: Provide all required accessories including, but not limited to: aluminum birdscreen, **[extended base to conform to NFPA 96 requirements for fan discharge a minimum of 40" above roof,]** fan UL-listed and labeled for grease removal (UL 762), **[grease drain connection and trap (for**

all kitchen hood exhaust fans),] [insulated motor heat baffle (for kitchen exhaust fans.)] [gravity] [motorized] backdraft dampers [with end switch (for all fans except kitchen hood exhaust fans)], prefabricated insulated aluminum roof curb, factory-mounted and wired [internal NEMA 1] [external NEMA 3R] disconnect switch and solid state fan speed controllers on direct drive units.

2.5 SIDEWALL PROPELLER EXHAUST FANS:

- A. General: Provide Greenheck Model SDE, SDP, and SBP or approved equal ACME, Cook or Carnes sidewall propeller exhaust fans with capacities as scheduled.
- B. Construction: Fans shall be axial type, belt or direct driven as scheduled. Blades shall be die-formed and welded to a steel hub. A polished steel fan shaft shall be mounted in permanently-lubricated, sealed ball bearing pillow blocks. The drive frame assembly shall be formed steel. The fan panel shall have prepunched mounting holes, formed flanges with welded corners, and a deep formed venturi. Fans shall bear AMCA rating seals for air and sound performance.
- C. Motors: Motors shall be 1750 rpm open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]**
- D. Accessories: Provide all required accessories including, but not limited to: mounting collar, factory-wired and mounted NEMA 1 disconnect switch, **[gravity] [motorized] backdraft damper [with end switch]**, and motor side fan guard (except on fans with reverse air flow).

2.6 IN-LINE EXHAUST/TRANSFER FANS:

- A. General: Provide Greenheck Model CSP, BCF, BSQ, BSQ-HP or DSQ or approved equal Acme or Cook in-line exhaust fans with capacities as scheduled.
- B. Construction: Fans shall be belt or direct driven in-line type with square heavy gauge galvanized steel housing with duct mounting collars shall have a galvanized or thermally fused epoxy finish. One or both sides shall be hinged and shall support the entire drive assembly and wheel allowing the assembly to swing out for cleaning, inspection, or service without dismantling the unit in any way. On belt drive models the motor shall be mounted on the hinged side exterior, isolated from the airstream. The motor shall be isolated from the airstream by a motor enclosure and shall draw cooling air from outside the fan housing.
- C. Wheels: The fan inlet shall be spun venturi throat overlapped by an aluminum backward inclined centrifugal wheel with spun cone for maximum performance. The fan wheel shall be statically and dynamically balanced.
- D. Insulation: The interior of the fan housing shall have one inch (1") thick, 3 PCF density internal sound absorbing fiberglass insulation to reduce operating noise levels.
- E. Drives: Motors shall be heavy duty type with permanently-lubricated, sealed ball bearings. The wheel shaft shall be ground and polished shafting mounted in heavy duty sealed pillow block bearings. Drives shall be sized for a minimum of 165% of driven horsepower. Pulleys shall be fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. An adjustable drive shall be used for balancing and then a fixed drive shall be provided. Motors shall be 1750 rpm open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]**
- F. Wiring: Flexible wiring leads shall be installed in conduit from the fan motor to an externally mounted junction box[, **motor speed controller (single phase units only)**] and disconnect switch, permitting access for service without disconnecting field wiring.
- G. Certification: All fans shall bear the AMCA-certified ratings seal for both air and sound performance.
- H. Accessories: Provide all required accessories including, but not limited to: Duct mounted automatic acting gravity type backdraft dampers of same size as fan housing, hanging support isolators with door side perpendicular to mounting surface, solid state fan speed controllers (direct drive units only) and belt guard for belt driven fans.

2.7 UTILITY EXHAUST FANS:

- A. General: Provide Greenheck Model SFD or approved equal Peerless or Trane utility exhaust fans with capacities as scheduled.
- B. Construction: Fans shall be belt or direct driven, single width, single inlet centrifugal blowers with discharge arrangement as shown on the drawings. The blower housing shall be of continuously welded construction which can be adjusted for discharge position. Housing supports shall have formed flanges and prepunched mounting holes. The blower wheel shall be steel of the forward curved type and shall be statically and dynamically balanced. A polished steel fan shaft shall be mounted in ball bearing pillow blocks. Bearings shall be grease lubricated.
- C. Finish: Entire exterior of the fan assembly shall be phosphatized, primed and finished with a baked enamel. **[Laboratory exhaust fans shall have a factory applied epoxy corrosion resistant coating applied to all surfaces exposed to the air stream.]**
- D. Motors: Motors for interior mounted fans shall be open dripproof (ODP) type and motors for exterior mounted fans shall be totally enclosed fan cooled (TEFC). Motors shall be 1750 rpm type of the horsepower and voltage scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]**
- E. Accessories: Provide all required accessories including, but not limited to: Vented weather hood with expanded metal outlet guard, access doors, shaft seals, factory-mounted and wired NEMA **[1] [3R]** disconnect switch, felt tipped automatic aluminum backdraft dampers, vibration isolators, belt guard, drain connections and weather hoods (where required).

2.8 UTILITY EXHAUST FANS:

- A. General: Provide Greenheck Model SFB, SWB, or approved equal Peerless or Trane exhaust fans with capacities and discharge arrangement as scheduled and shown on the Drawings.
- B. Configuration: Fans shall be a belt drive, single width, single inlet utility vent set with forward curved or backward inclined centrifugal fan wheel as scheduled.
- C. Housing: The fan housing and inlet cones shall be constructed of heavy gauge steel with lock-formed seams to prevent leakage. Housing supports and drive frame shall be constructed of welded steel members to prevent vibration and rigidly support the fan shaft and bearings.
- D. Wheels: Fan wheels shall be constructed of formed steel blades securely attached to the wheel backplate and cone. Each wheel and shaft shall be statically and dynamically balanced.
- E. Fan Shafts: Fan shafts shall be precision tuned, ground and polished steel shafts, sized so that the first critical speed is a minimum of 25% over the maximum operating speed. Fan shaft shall have pillow block bearings. All fan bearings shall be factory-lubricated and equipped with standard hydraulic grease fittings. Extended lube lines shall be furnished where bearings are not accessible and shall terminate on the outside of drive end of each unit including extension to allow greasing without removal of drive guard.
- F. Drives: V-belt fan drives with variable pitch motor sheave shall be selected for 150% of motor horsepower and anti-static belts shall be furnished. Drive guards shall have accessible opening to read rpm.
- G. Motors: Fan motors shall be ball bearing 1750 rpm open dripproof (ODP) type for indoor use and shall have electrical characteristics as scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]** Motor base shall be equipped with adjustable base rails.
- H. Finish: The entire fan assembly shall be phosphatized and painted with the manufacturers standard paint finish.
- I. Certification: Fan performance shall be based on tests conducted in accordance with AMCA Standard 210 test code for air moving devices. Fans shall be licensed to bear the AMCA Certified Rating Seal for air performance.
- J. Accessories: Provide all required accessories including, but not limited to, belt guard, access door, **[gravity] [motorized] backdraft damper [with end switch], [inlet] [discharge] guard[, drain connection] and [a motor and drive weather load].**

2.9 UPBLAST SMOKE EXHAUST FANS:

- A. General: Provide Greenheck Model TAUB-HT or approved equal roof-mounted upblast tube axial smoke exhaust fans capable of operating for a minimum of 4 hours at an exhaust air temperature of 500°F.
 - B. Construction: Fan housing shall be constructed of heavy gauge welded steel and shall be designed for curb mounting using a curb cap with an integral flanged venturi inlet. The fan housing shall have a reinforced steel windband and outlet screen from discharge damper protection. Bearing and motor supports shall be constructed of structural steel shapes and welded to the fan housing. A ventilated weatherproof motor cover shall be provided.
 - C. Dampers: Provide spring-loaded steel butterfly damper on the fan discharge. Damper shall be gasketed in the closed position to minimize leakage and be provided with damper stops to maintain proper damper position when the fan is operating. The damper shall be held closed by a resettable McCabe type electrothermal link which shall open the damper at 165°F ambient temperature or upon a 120 volt signal on fan start-up.
 - D. Fans: Propeller construction shall be fabricated steel, with the fan hub key locked to the fan shaft. Fans and shafts shall be statically and dynamically balanced.
 - E. Fan Shafts: Fan shafts shall be precision tuned, ground and polished steel shafts, sized so that the first critical speed is a minimum of 25% over the maximum operating speed. Fan shaft shall have pillow block bearings. All fan bearings shall have a minimum B-10 life as defined by AFBMA of 25,000 hours, factory-lubricated and equipped with standard hydraulic grease fittings. Extended lube lines shall be furnished where bearings are not accessible and shall terminate on the outside of drive end of each unit including extension to allow greasing without removal of drive guard. Heat slingers shall be mounted on the fan shaft to dissipate heat from the fan shaft and draw cooling air over the bearings, shaft, and drive.
 - F. Drives: V-belt fan drives with variable pitch motor sheave shall be selected for 150% of motor horsepower and anti-static belts shall be furnished. Drive guards shall have accessible opening to read rpm. Belt and bearing tubes shall be constructed of welded heavy gauge steel and provided with ventilation for proper cooling of belts, bearings, and drives.
 - G. Motors: Fan motors shall be ball bearing 1750 rpm open dripproof (ODP) type for indoor use and shall have electrical characteristics as scheduled. Motor base shall be equipped with adjustable base rails.
 - H. Finish: The entire fan assembly shall be phosphatized and painted with the manufacturers standard paint finish.
 - I. Certification: Fan performance shall be based on tests conducted in accordance with AMCA Standard 210 test code for air moving devices. Fans shall be licensed to bear the AMCA Certified Rating Seal for air performance.
 - J. Accessories: Provide all required accessories including, but not limited to, an outlet screen, bolted access door, and a factory-mounted and wired heavy duty NEMA 3R disconnect switch.
- 2.10 VANE AXIAL SUPPLY/EXHAUST FANS:
- A. General: Provide Woods of Colchester Limited or approved equal belt or direct driven in-flight controllable pitch and manually adjustable fixed pitch vane axial type supply and exhaust fans of the type, size, and capacity scheduled.
 - B. Ratings: The fan shall deliver the volume and pressure specified in the fan schedule when tested in accordance with AMCA Standard 210.
 - C. Casings: The fan casing will consist of two sections, each 3/16" minimum thickness mild steel, joined with bolted flanges. The motor will be supported by the fabricated steel structure of 3/16" minimum thickness welded to one of the ducts. The other duct will be removable for access to the impeller. Drilled flanges will be provided for attachment of accessories or ductwork. The casing shall have an integral support frame and plate for mounting the motor on direct drive fans and internal bearing supports and an external motor mounts on belt drive fans. The casing and drilled flanges shall be hot dip galvanized.
 - D. Fan Impellers: The impeller hub shall be cast in high strength heat-treated aluminum alloy precision-machined and balanced. Blades shall be of aerofoil section cast from silicon aluminum alloy and mounted on thrust bearings with grease retaining features such that the bearings shall be fully

submersed in grease. All hub and blade materials shall be examined by X ray before machining. The manufacturer shall have available, laboratory evidence that impeller hubs and blades are suitable designed for normal running conditions and that fluctuating stresses in use are sufficiently low to ensure that no premature failure will occur due to metal fatigue.

- E. Fixed Adjustable Pitch Fans: The fan impeller pitch angle shall be manually adjustable in the field.
- F. In-flight Controllable Fans: The impeller blades shall be actuated in flight by an internal pneumatic actuator built into the hub and providing stepless control of the blade pitch angle. A pilot positioner shall be provided to ensure minimum control hysteresis. Where scheduled, the fan blades shall be reversible in-flight to reverse the airflow direction through the fan. A blade angle indicator shall be provided on the outside of the fan housing. The pneumatic operator shall be factory-adjustable to control fan blade angle from minimum to maximum pitch from a 3 to 15 psi pneumatic signal **[and for pitch reversing, where applicable]**.
- G. Balancing: After assembly the fan shall be dynamically balanced while on anti-vibration mountings giving over 90% isolation. The balance standard shall be in accordance with ISO 2372;1974 Quality Grade C for Class II machines. Maximum vibration velocity shall not exceed 0.14 in/sec r.m.s. on 60 Hz supplies over the full pitch angle range, when measured at the fan mounting feet.
- H. Certification: The fan manufacturer shall supply a test certificate for each fan showing the voltage, current, frequency, kilowatts input, degree of balance and control characteristic (actuator movement against control signal). The fan pitch angle for adjustable fixed pitch fans shall be adjusted at the factory to meet scheduled conditions.
- I. Characteristics: The aerodynamic design of the fan shall be such that the maximum power absorbed by the impeller occurs within the normal working range such that the fan has a non-overloading characteristic.
- J. Impeller Attachment: The impeller shall be secured to the motor or fan shaft by a key and keyway. Axial location shall be provided by a collar or a shoulder on the drive shaft together with a retaining washer and a screw fitted into a tapped hole in the end of the shaft. The screw shall be locked in position.
- K. Direct Drive Motors: Motors shall be totally enclosed fan cooled (TEFC) with Class F insulation and 1.15 service factor. Motor bearings shall be selected for a minimum L-10 life of 20,000 hours. Grease lubrication lines shall be brought to outside of the fan casing and labeled. Motor wiring shall be factory-extended to a junction box installed on the outside of the fan housing.
- L. Belt Drive Motors: Fan motors shall be ball bearing 1750 rpm open dripproof (ODP) type for indoor use and shall have electrical characteristics as scheduled. **[Motors 1 hp and larger shall be of the high efficiency, energy efficient type.]** Motor base shall be equipped with adjustable base rails.
- M. Belt Drives: V-belt fan drives with variable pitch motor sheave shall be selected for 150% of motor horsepower and anti-static belts shall be furnished. Drive guards shall have accessible opening to read rpm.
- N. Fan Shafts: Fan shafts shall be precision tuned, ground and polished steel shafts, sized so that the first critical speed is a minimum of 25% over the maximum operating speed. Fan shaft shall have pillow block bearings. All fan bearings shall be factory-lubricated and equipped with standard hydraulic grease fittings. Extended lube lines shall be furnished where bearings are not accessible and shall terminate on the outside of drive end of each unit including extension to allow greasing without removal of drive guard.
- O. Accessories: Provide all required accessories including, but not limited to:
 - 1. Inlet bell mouth fittings with guards.
 - 2. Outlet guard.
 - 3. Outlet cone.
 - 4. Inlet and outlet attenuators.
 - 5. Flange mounted flexible connections.
 - 6. Horizontal or vertical mounting brackets as required for isolated fan mounting.

2.11 AIR INTAKES:

- A. General: Provide ACME or approved equal Greenheck, Cook or Carnes roof-mounted air intakes with capacities as scheduled.
- B. Construction: Construction of the housing shall be aluminum. Intakes shall be constructed to withstand winds up to 150 mph.
- C. Accessories: Provide all required accessories including, but not limited to: aluminum birdscreen, gravity or motorized (as scheduled) backdraft dampers and prefabricated insulated aluminum roof curb.

2.12 RELIEF VENTS:

- A. General: Provide ACME or approved equal Greenheck, Cook or Carnes roof-mounted air relief vents of the type and capacities as scheduled.
- B. Construction: Construction of the housing shall be aluminum. Vents shall be constructed to withstand winds up to 150 mph.
- C. Accessories: Provide all required accessories including, but not limited to: aluminum birdscreen, gravity or motorized (as scheduled) backdraft dampers and prefabricated insulated aluminum roof curb.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. General: Installer shall examine conditions under which fans, outside intakes, and relief vents 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.

3.2 INSTALLATION:

- A. General: Install fans, outside intakes, and relief vents where shown, in accordance with manufacturer's written instructions and recognized industry practices to ensure that fans, outside intakes, and relief vents comply with requirements and serve intended purposes. Comply with NEMA standards and requirements of NEC.
- B. Curb-mounted Fans: All fans mounted on roof curbs shall be securely attached to the roof curb with appropriate fasteners located 8" on center with a minimum of two fasteners per side by this Contractor. The roof curb shall be securely attached to the building structure by the General Contractor.
- C. Insulation: Refer to Section 23 05 48 for fan insulation requirements.
- D. Housekeeping Pads/Vibration Isolation: Refer to Section 23 03 00 and Section 23 05 48 for applicable requirements.

3.3 COORDINATION:

- A. General: This Contractor shall be responsible for coordinating installation requirements and provisions with the work of other Divisions and the General Contractor.
- B. Coordinate all required fan motor horsepower, voltages and locations with Electrical Contractor prior to purchase.
- C. **All fans with 2000 cfm or greater airflow shall have a firestat with manual reset set to open at 50°F, above maximum system operating temperature to interrupt electric current to the fan motor in case of fire. Firestat shall be furnished and installed by [this Contractor with wiring of firestat by the Electrical Contractor.] [the Temperature Controls Subcontractor. Refer to Section 23 06 00 for control requirements].**
- D. Coordinate all roof mounted fan curb openings with General Contractor prior to roofing installation.

3.4 START-UP SERVICES:

- A. General: The fan supplier shall provide fan checkout, start-up, testing and adjusting of system components for the vane axial fan systems. The fan supplier shall also train the Owner's Engineer in the proper operation and maintenance of these fans.

3.5 TESTING:

- A. General: Test and adjust all installed fans to verify proper operation as specified herein and as recommended by the manufacturers. Where specified hereinabove, start-up, testing, and adjustment shall be provided by a representative of the equipment supplier.
 - B. Refer to Section 23 05 93 for additional start-up, testing, and adjustment requirements.
- 3.6 IDENTIFICATION:
- A. Refer to Section 23 03 00, for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 82 20

UTILITY EXHAUST FANS

Furnish and install Greenheck Model SWB or approved equal ACME or Cook exhaust fans as scheduled. Fan shall be a belt drive, single width, single inlet utility vent set with an aluminum backward inclined non-overloading centrifugal fan wheel. Fan shaft shall have pillow block bearings. All fan bearings shall be factory lubricated and equipped with standard hydraulic grease fittings. Extended lube lines shall be furnished where bearings are not accessible and shall terminate on the outside of drive end of each unit including extension to allow greasing without removal of drive guard.

V-belt fan drives with variable pitch motor sheave shall be selected for 150% of motor horsepower and anti-static belts shall be furnished. Drive guards shall have accessible opening to read rpm.

Fan housing and drive guard shall be minimum 16 gauge arc-welded steel. Housing shall have a 1" FPT coupling welded to bottom of housing with automatic trap drain provided and installed by Mechanical Contractor to automatically drain the fan housing. Fan motors shall be ball bearing 1750 rpm open dripproof (ODP) type for indoor use and shall have electrical characteristics as scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 15100).]** Motor base shall be equipped with adjustable base of rails.

All parts of the fan that come into contact with the air-stream shall be coated with a high temperature acid resistant epoxy coating.

Fan accessories shall include belt guard, heat slinger wheel, high temperature drive belts, high temperature wheel bearings and bearing grease, access door, gravity backdraft damper, discharge guard and factory installed disconnect switch.

SMOKE REMOVAL FANS

Furnish and install Flakt Products, Inc. Model AV or approved equal belt driven fixed pitch axial flow type smoke removal fans of the size and capacity scheduled.

Fans shall be Arrangement 9 V-belt drive with fan rotor mounted on separate shaft and bearings in an enclosed tube with fixed pitch belt drive with a 1.5 safety factor.

Fan casings shall be welded of hot-rolled steel plate .135" in small sizes up to 28" with continuously welded flanges. The next fan sizes up to 50" shall be 3/16" thick with flanges rolled at inlet and outlet. Sizes of 50" or greater diameter shall be of 1/4" plate steel with rolled flanges at inlet and outlet. Concentricity of fan casings shall be insured through the use of welding jigs and fixtures. A fabricated adjustable steel motor support of plate steel shall be supported by adjustable rods welded to a base on the outside of the fan casing.

Fan casings shall be fitted with mounting legs or hanging clips as shown on the drawings. Fan mounting legs shall be fabricated from minimum 3/16" steel plate suitably braced to insure stability and rigidity. Clips for horizontal suspension shall be of minimum 3/8" steel plate mounted at fan center line. Clips for vertical suspension shall be mounted at center of moment of inertia of fan assembly.

Fan rotor shall be of fabricated steel. Fan blades shall be designed for maximum efficiency and be air-foil shaped, varying in twist and width from base to tip. Blade tip clearance shall be within tolerance to meet certified performance of fan.

The fan rotor assembly shall be statically and dynamically balanced. Belt drive rotors shall be installed on their fan shafts for balancing to tolerances as listed below in mils double amplitude:

FAN RPM RANGE	MILS PK-PK
2400 - 3600	0.4
1800 - 2400	0.6
1200 - 1800	0.8
900 - 1200	1.2
LESS THAN 900	1.6

The fan rotor shall be secured on the fan shaft by a key and keyway, and by locking hardware threaded on the end of the shaft.

Fan motors shall be foot-mounted NEMA standard **[open dripproof (ODP)] [totally enclosed fan cooled (TEFC)]** continuous duty, ball bearing, with Class "B" insulation. Motor leads shall terminate in the

conduit box mounted on the exterior of the motor. External grease fittings with extended grease leads shall be supplied for lubrication of the fan shaft bearings.

After fabrication, fans shall be prime coated and finish painted. Zinc chromate epoxy primer shall be applied after surfaces are cleaned and degreased. Finish coat shall be air dry acrylic enamel.

All fan bearings shall have a B-10 life as defined by AFBMA of at least 25,000 hours.

Fans shall be furnished with high temperature belts, high temperature grease, heat slinger, shall be all steel construction per City of Houston High Rise Code requirements and shall be suitable for continuous operation with 500_o_F exhaust air.

SMOKE REMOVAL FANS

Furnish and install Industrial Air, Inc. Series 047 or approved equal smoke removal fans of the size and capacity scheduled.

Fan shall be of a bifurcated vane axial design with an insulated motor well and heat slinger induced air cooling and shall be suitable for use with exhaust air temperatures up to 500_o_F. Cooling air intakes shall have louvered covers.

Fan shall be direct drive type with high temperature aluminum alloy blades. Blades shall be manually adjustable from the front of the wheel.

Fan shall be designed for duct inlet and outlet.

Fan motor shall be factory installed and aligned and to entire rotating assembly shall be statically and dynamically, balanced.

SMOKE REMOVAL FANS

Fan shall be an up-blast propeller type constructed to meet The City of Houston High Rise Code for smoke exhaust and shall be of the size and capacity as indicated on the drawings.

Construction features shall include:

- Painted Steel curb
- Heavy duty painted steel curb cover
- Painted steel weather cover over motor
- Butterfly dampers with rubber weather seal
- Sheaves and belts out of the air stream
- Welded drum assembly welded to curb cap

Fan shall be a Cincinnati model RA or approved equal.

HOOD EXHAUST FANS

Furnish and install Dual Industries Model [????] or approved equal utility fans of the size and capacities scheduled.

Fan shall be belt driven, single width, single inlet, centrifugal blower with vertical discharge. The blower housing shall be PVC with PVC inlet and outlet angle flanges and PVC drain. Frame shall be phenolic coated steel. Fan wheel shall be PVC coated steel. Motor shall be totally enclosed, fan cooled, ball bearing type.

Other features to include: heavy angle iron bracing. over capacity shaft and oil-type, pillow block ball bearings, formed PVC venturi inlet, 155_o_F operating temperature, OSHA belt and shaft guards and ventilated weatherproof PVC motor and drive housing.

The fan and wheel inlet cone shall be non-sparking aluminum and of the high performance, centrifugal blower type. Wheel shall be statically and dynamically balanced.

Motor and drives shall be isolated from the exhaust airstream. Motors shall be of the heavy duty type with permanently lubricated, sealed ball bearings. Air for cooling the motor shall be taken into the motor chamber by means of an air tube from a location free of discharge contaminants.

The entire drive assembly and wheel, as a unit, shall be removable through the support structure without dismantling fan housing. The wheel shaft shall be mounted in heavy duty ball bearings. Drives shall be sized for 165% of driven horsepower. Pulleys shall be adjustable cast iron type keyed to the fan and motor shafts. The entire drive assembly shall be mounted on rubber vibration isolators.

Motors shall be 1750 RPM open dripproof (ODP) type for indoor use and totally enclosed fan cooled (TEFC) type for exterior use and shall be of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 15100).]**

Fan accessories shall include: 1/2" mesh aluminum birdscreen, gravity backdraft damper, disconnect switch and weather hood (where applicable).

FUME HOOD EXHAUST FAN

Furnish and install Greenheck Model SWB or approved equal ACME or Cook exhaust fans as scheduled. Fan shall be a belt drive, single width, single inlet utility vent set with an aluminum backward inclined non-overloading centrifugal fan wheel. Fan shaft shall have pillow block bearings. All fan bearings shall be factory lubricated and equipped with standard hydraulic grease fittings. Extended lube lines shall be furnished where bearings are not accessible and shall terminate on the outside of drive end of each unit including extension to allow greasing without removal of drive guard.

V-belt fan drives with variable pitch motor sheave shall be selected for 150% of motor horsepower and anti-static belts shall be furnished. Drive guards shall have accessible opening to read RPM.

Fan housing and drive guard shall be minimum 16 gauge arc-welded steel. Housing shall have a 1" FPT coupling welded to bottom of housing with automatic trap drain provided and installed by Mechanical Contractor to automatically drain the fan housing. Fan motors shall be ball bearing 1750 RPM open dripproof (ODP) type for indoor use and totally enclosed fan cooled (TEFC) for exterior use and shall have electrical characteristics as scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]** Motor base shall be equipped with adjustable base of rails.

All parts of the fan that come into contact with the air-stream shall be coated with a high temperature acid resistant epoxy coating.

Fan accessories shall include belt guard, weatherhood, access door, gravity backdraft damper and discharge guard.

FILTERED DOWNBLAST ROOF MOUNTED FAN

Furnish and install a Greenheck Model RSF or approved equal roof mounted supply air fans with capacities as scheduled.

Fans shall be a belt drive, double width, double inlet, forward curved centrifugal blower type with the blower assembly mounted on suitable vibration isolators. Drive shall be designed for a minimum of 165% of driven horsepower and shall be furnished with cast iron, adjustable type drive sheaves.

Motors shall be 1750 RPM open drip proof type of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]** The motor and blower shall have permanently lubricated, sealed ball bearings.

The fan housing shall be heavy gauge galvanized steel **[and the unit shall be designed to elevate the air intake a minimum of 3 feet above the roof.]** The unit wind band shall be adequate to prevent moisture from entering the building. The fan cover shall be insulated and shall be securely held in place.

Reusable 1" permanent aluminum filters shall be provided. Fan accessories shall include a duct adapter, an extended insulated base roof curb **[to provide the minimum 3' intake height]**, a disconnect switch and a **[gravity] [pneumatic] backdraft damper. [Refer to Section 23 06 00 for damper operators and controls.]**

The fan unit shall bear the AMCA certified ratings seal for air performance with filters in place.

UNFILTERED DOWNBLAST ROOF MOUNTED FAN

Furnish and install a Greenheck FFS Series or approved equal power roof ventilator with capacities as scheduled.

Ventilator housing shall be heavy duty aluminum with rolled interlocking seams for reinforcement. The hood top shall be hinged for easy access to the fan.

Drives shall be adjustable and shall be sized for 165% of driven horsepower and shall be mounted on vibration isolators. The fan shall be axial propeller type with sealed ball bearing and cast iron drive sheaves. Motors shall be 1750 open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type. (Refer to Section 23 04 00).]** The motor and blower shall have permanently lubricated, sealed ball bearings.

Accessories shall include an expanded aluminum birdscreen, duct adapter, an insulated aluminum roof curb and a disconnect switch.

The fan unit shall bear AMCA seals for sound and air with the birdscreen in place.

ROOF MOUNTED PROPELLER SUPPLY FANS

Furnish and install Greenheck Model PBS, PDS or approved equal ACME, Cook or Carnes roof mounted propeller fans with capacities as scheduled.

Fans shall be axial type, belt or direct driven as scheduled. Blades shall be die formed and welded to a steel hub. A polished steel fan shaft shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. The drive frame assembly shall be formed steel. The fan panel shall have prepunched mounting holes, formed flanges with welded corners, and a deep formed venturi. A special arrangement for supply air shall be used with the fan panel reversed so that air flows through the panel in the proper direction in respect to the inlet venturi. Fans shall bear AMCA ratings seals for air and sound performance.

Round low profile discharge hood shall be fastened to roof curbs with heavy duty full length piano hinge. Fan motor brackets shall mount down inside roof curb to keep overall unit height as low as possible.

Motor shall be 1750 RPM open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]**

Accessories shall include 1/2" mesh birdscreen, prefabricated insulated aluminum roof curb, damper tray, disconnect switch, gravity backdraft damper. Refer to Section 15900 for controls.

SIDEWALL PROPELLER SUPPLY FANS

Furnish and install Greenheck Model SDE, SBPS or approved equal ACME, Cook or Carnes sidewall propeller fans with capacities as scheduled.

Fans shall be axial type, belt or direct driven as scheduled. Blades shall be die formed and welded to a steel hub. A polished steel fan shaft shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. The drive frame assembly shall be formed steel. The fan panel shall have prepunched mounting holes, formed flanges with welded corners, and a deep formed venturi. A special arrangement for supply air shall be used with the fan panel reversed so that air flows through the panel in the proper direction in respect to the inlet venturi. Fans shall bear AMCA ratings seals for air and sound performance.

Accessories shall include mounting collar, disconnect switch, pneumatic backdraft damper with end switch and motor side fan guard. Refer to Section 23 06 00 for damper operators and controls.

SIDEWALL MOUNTED PROPELLER SUPPLY FANS

Furnish and install Greenheck Model SPN or approved equal ACME, Cook or Carnes sidewall mounted propeller fans with capacities as scheduled.

Fans shall be axial type, belt or direct driven as scheduled. Blades shall be die formed and welded to a steel hub. A polished steel fan shaft shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. The drive frame assembly shall be formed steel. The fan panel shall have prepunched mounting holes, formed flanges with welded corners, and a deep formed venturi. A special arrangement for supply air shall be used with the fan panel reversed so that air flows through the panel in the proper direction in respect to the inlet venturi. Fans shall bear AMCA ratings seals for air and sound performance.

Motors shall be 1750 RPM open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]**

Accessories shall include mounting collar, disconnect switch, pneumatic control damper with end switch and motor side fan guard. Refer to Section 15900 for damper operators and controls.

IN-LINE SUPPLY FANS

Furnish and install Greenheck Model [????] or approved equal ACME, Cook or Carnes in-line supply fans with capacities as scheduled.

Fans shall be belt or direct driven in-line type with square heavy gauge galvanized steel housing which shall have a thermally fused epoxy finish. One of the sides shall be hinged and shall support the entire drive assembly and wheel allowing the assembly to swing out for cleaning, inspection, or service without dismantling the unit in any way. On belt drive models the motor shall be mounted on the hinged side exterior isolated from the airstream.

The belt and pillow block ball bearings shall be protected from the airstream by an enclosure. The shaft shall be keyed to both the wheel and pulley. On direct drive models the motor shall be isolated from the airstream by a motor enclosure and shall draw cooling air from outside the fan housing.

The fan inlet shall be spun venturi throat overlapped by a backward curved centrifugal wheel with spun cone for maximum performance.

The interior of all in-line fan housing shall have 1" thick, 3 P.C.F. density internal sound absorbing fiberglass insulation to reduce operating noise levels.

Motors shall be 1750 RPM open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]**

Fan accessories shall be as follows: Duct mounted automatic acting gravity type backdraft dampers of same size as fan housing, hanging support isolators with door side perpendicular to mounting surface and belt guard for belt driven fans.

UTILITY SUPPLY FANS

Furnish and install Greenheck Model AFSW or approved equal Peerless or Trane utility supply fans with capacities as scheduled.

Fans shall be of the centrifugal type with airfoil wheels.

The housing shall be constructed of continuously welded heavy-gauge steel to assure no air leakage. The housing and bearing support shall be constructed of structural steel members to prevent vibration and rigidly support the shaft and bearings.

All structural parts shall be phosphatized, primed and coated with a baked enamel finish.

Non-overloading single and double width wheels shall be constructed of heavy gauge, airfoil blades securely welded to the wheel cone and a heavy gauge backplate. The wheel cone and unit inlet cone shall be carefully matched and have precise running tolerances to provide for maximum efficiency. Each fan wheel shall be statically and dynamically balanced before being assembled into the fan.

Turned, precision ground and polished steel shafts shall be sized so the first critical speed is at least 25% over the maximum operating speed for each pressure class. Close tolerances shall be maintained where the shaft makes contact with the bearing. Bearings shall be heavy duty grease lubricated, self aligning ball bearing or roller pillow block type. Bearings shall be selected for a minimum of 400,000 hours life at maximum operating speed for each pressure class.

Inlet flanges welded to the inlet collar and outlet flanges welded to the fan outlet shall be provided flanged duct connections.

A 1" threaded drain connection with a plug shall be provided to drain moisture from the bottom of the fan housing.

A totally enclosed belt guard with provisions for measuring fan RPM without removing the guard shall be provided.

A motorized parallel blade backdraft damper with galvanized steel frame, aluminum blades, felt edge seals and steel end seals shall be provided mounted to each fan. Refer to Section 15900 for pneumatic operators and controls.

Fan performance shall be based on tests conducted in accordance with AMCA Standard 210 test code for air moving devices and fans shall be licensed to bear the AMCA Certified Ratings Seal.

After assembly each fan shall be given a final balance test at the specified operating RPM to insure smooth vibration free operation.

Outside air fans shall be externally insulated in the field.

Motors for interior mounted fans shall be open dripproof (ODP) type and motors for exterior mounted fans shall be totally enclosed fan cooled (TEFC). Motors shall be 1750 RPM type of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]**

Accessories shall include **[vented weather hood with]** expanded metal inlet guard, factory mounted disconnect switch, felt tipped automatic aluminum backdraft dampers, vibration isolators and drain connections.

STAIRWELL PRESSURIZATION FANS

Furnish and install Flakt Products, Inc. Series [????] or approved equal in-flight adjustable vaneaxial stairwell pressurization fans as scheduled.

[Fans shall be Arrangement 4, Type 2 with the fan rotor mounted directly on the drive motor shaft and the motor enclosed entirely within the fan casing. Fans shall be designed for horizontal or vertical mounting as scheduled and shall be of a weatherproof design when indicated or required.]

[Fans shall be Arrangement 4, Type 3 having the fan rotor mounted directly on the drive motor shaft, with the drive motor supported on a structural steel base upstream of the fan rotor and external to the fan casing. The inlet bell and fan casing shall also be supported from the structural steel base. A protective wire cage shall be supplied at the fan inlet covering drive motor and inlet bell.]

Fans shall consist of a fan casing followed by a separate removable guide vane section. Fan casings shall be welded of hot-rolled steel plate 3/16" thick in sizes through 50" diameter with 3/16" thick flanges continuously welded at inlet and outlet. Sizes greater than 50" diameter shall be of 1/4" thick steel with 1/4" thick flanges. Concentricity of fan casings shall be insured through the use of welding jigs and fixtures. A fabricated steel motor support shall be welded into the inlet end of the fan casing.

Guide vane sections shall be welded of 12 gauge steel and shall be fitted with a removable panel for access to fan rotor and control section. The guide vane section shall be arranged for attachment of a flexible connection at the discharge.

Fan casings shall be fitted with mounting legs or hanging clips as shown on the drawings. Fan mounting legs shall be fabricated from steel plate suitably braced to insure stability and rigidity. Clips for vertical support shall be mounted at center of moment of inertia of fan assembly.

Fan blades and hub shall be aluminum castings. Hub shall be heat treated alloy 356-T6 and blades shall be alloy 356. Fan blades shall be designed for maximum efficiency and be air-foil shaped, varying in twist and width from base to tip. Blade tip clearances shall be within tolerance to meet certified performance of fan.

The center of the hub shall be equipped with a blade operating mechanism. An **[electronic] [pneumatic]** operator shall be furnished with linkage to operate the fan blades. The fan blade angle shall be variable from zero to maximum angle. Mechanical adjustable stops shall be furnished for maximum angle. The **[electronic] [pneumatic]** operator shall be factory installed, complete with **[wiring] [piping]** and linkage to a positioning device mounted external to the vane section. **[Power shall be supplied to the electronic activator at the required voltage by the Division 16 Contractor.] [Control air shall be supplied to the pneumatic operator by the Temperature Controls Subcontractor at the required pressure.] [Air pressure to the pneumatic operator shall be 65 PSIG. The positioning device shall operate with a 3-15 PSIG control signal from a sensing device and controller furnished and mounted by the control manufacturer as specified elsewhere. The positioning device shall be reverse acting wherein the 3 PSIG control signal requests maximum blade angle and the 15 PSIG control signal requests minimum blade angle.]**

Operation of the control system shall be such that the fan blades on the lower fans go to the maximum angle upon loss of control **[power] [air]** and the upper fans go to the zero angle upon loss of control **[power] [air]**. The fan rotor assembly shall be statically and dynamically balanced. Direct drive rotors shall be balanced on their motor shafts to tolerances as listed below in mils double amplitude:

FAN RPM	MILS PK-PK
1760	0.8
1180	1.2
880	1.6

[Fan Motors shall be totally enclosed air over (TEAO), continuous duty, ball bearing, with class "B" insulation. Motor leads shall be extended through an air tight conduit to a suitably sized conduit box on the side of the fan casing. Provide with external grease fittings and extended grease leads.]

[Fan motors shall be foot-mounted NEMA standard open drip proof (ODP) continuous duty, ball bearing, with Class "B" insulation. Motor leads shall be extended through an air tight conduit to a suitably sized conduit box mounted on the exterior of the fan casing. External grease fittings with extended grease leads shall be supplied for lubrication of the motor bearings.]

After fabrication, fans shall be prime coated and finish painted. Zinc chromate epoxy primer shall be applied after surfaces are cleaned and de-greased. Finish coat shall be air dry acrylic enamel.

Fan performance data shall be the result of test data obtained in an AMCA approved laboratory using applicable portions of AMCA Standard 210 for flow and Standard 300 for sound power levels.

ELEVATOR HOISTWAY PRESSURIZATION FANS

Furnish and install Flakt Products, Inc. Series [????] or approved equal manual (fan stopped) adjustable vane axial elevator hoistway pressurization fans as scheduled.

Fans shall be Arrangement 4, Type 2 having the fan rotor mounted directly on the motor shaft with the assembly enclosed entirely within the fan casing.

Fan casings shall be welded of hot-rolled steel plate 3/16" thick with 3/16" thick flanges continuously welded at inlet and outlet. Concentricity of fan casings shall be insured through the use of welding jigs and fixtures. A fabricated steel motor support of not less than 1/4" plate steel shall be welded into the inlet end of the fan casing.

Fan casings shall be fitted with mounting legs or hanging clips as shown on the drawings. Fan mounting legs shall be fabricated from minimum 3/16" steel plate suitably braced to insure stability and rigidity. Clips for horizontal suspension shall be of minimum 3/8" steel plate mounted at fan center line clips for vertical suspension shall be mounted at center of moment of inertia of fan assembly.

Fan casing shall be fitted with an access panel for external adjustment of blade pitch angle. Access panel shall provide unimpeded accessibility for adjusting blade angle.

Fan blades and hubs shall be aluminum castings, alloy 356. Fan blades shall be designed for maximum efficiency and be air-foil shaped, varying in twist and width from base to tip. Blade tip clearance shall be within tolerance to meet certified performance of fan. Fan hub shall be a one piece aluminum casting and shall have a vernier scale to indicate blade position for each blade.

Fan blade pitch angle shall be individually manually externally adjustable through an access panel of the fan casing. External adjustment of blade angle shall be accomplished without disturbing the installation of removing fan from ductwork.

The fan rotor assembly shall be statically and dynamically balanced. Direct drive rotors shall be installed on their motor shafts to tolerances as listed below in mils double amplitude:

__FAN RPM__	__MILS PK-PK
3550	0.4
1760	0.8
1180	1.2
880	1.6

The fan rotor shall be secured on the motor shaft by a key and keyway, and by a locking bolt threaded into the motor shaft.

Fan motors shall be foot-mounted NEMA standard open drop proof (ODP) continuous duty, ball bearing, with Class "B" insulation. Motor leads shall be extended through an air tight conduit to a suitable sized conduit box mounted on the exterior of the fan casing. External grease fittings with extended grease leads shall be supplied for lubrication of the motor bearings.

After fabrication, fans shall be prime coated and finish painted. Zinc chromate epoxy primer shall be applied after surfaces are cleaned and de-greased. Finish coat shall be air dry acrylic enamel.

Fan performance data shall be the result of test data obtained in an AMCA approved laboratory using applicable portions of AMCA standard 210 for flow and Standard 300 for sound power levels.

Return Air Fans

Furnish and install Trane or an approved equal centrifugal return air fans with capacities as scheduled.

Fans shall include housing, wheel, fan shaft, bearings and side support structure as a factory assembled unit. All sheet metal parts shall be cleaned, conditioned and painted with enamel primer finish prior to final assembly. A final coat of gray enamel is applied to all exterior surfaces after assembly.

Fans shall have curved scroll housings with lockseam or spot welded construction with discharge configuration as shown on the Drawings. All housings are reinforced with rigid bracing to increase structural integrity.

Bearing support brackets are positioned to directly oppose belt tension forces.

Inlet collars on all single width fans extend beyond the fan housing to provide an uninterrupted duct connection. Slip joint discharge duct connections shall be provided.

Precisely positioned cutoffs and aerodynamically spun inlet cones shall provide smooth air flow through the fan and minimum turbulence.

Fan wheels shall non-power-overloading with forward curved, backwardly inclined air foil blades or backwardly inclined, plate type blades.

Blades on all sizes shall be securely welded to the spun rim and to the hub plate. Hubs shall be close grained cast iron. All wheels shall be carefully trued after assembly and dynamically balanced. Wheels shall be keyed to the shaft.

Fan shafts shall be solid AISI C-1040 or 1045 hot rolled steel accurately turned and polished. Close tolerances shall be maintained where the shaft makes contact with the bearings.

Bearings shall be grease lubricated, precision anti-friction extra heavy duty, split pillow block type with tapered, double spherical rollers selected for a minimum average life (AFBMA L-50) in excess of 400,000 hours operation at maximum cataloged operating conditions. Extended grease lines shall be provided as required.

Motors shall be 1750 RPM open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]**

Fans shall be tested and rated in accordance with AMCA Standard 210 and the Certified Ratings Program and shall be licensed to bear the AMCA Certified Ratings Seal.

BUILT-UP AIR HANDLING UNIT SUPPLY FAN

Furnish and install Peerless Electric or approved equal supply fans of the size and capacity scheduled. Fans shall be of the belt driven, single width, backward incline, non-overloading air foil blade, centrifugal type.

Fans shall be Arrangement 3 V-belt drive. Backward inclined airfoil blades shall be continuously seam welded to backplate and wheel cove. Fan shaft shall have pillow block bearings.

Fan shall be tested in accordance with the latest AMCA fan test procedures and shall bear an AMCA seal.

Fan casings shall be fitted with heavy angle or channel frame suitable for mounting on concrete pad. Fan mounting shall be fabricated from minimum 3/16" steel plate suitably braced to insure stability and rigidity.

Provide belt guard.

The fan assembly shall be certified to be statically and dynamically balanced at the factory.

Fan motors shall be foot-mounted NEMA standard open dripproof (ODP) continuous duty, ball bearing, with Class "B" insulation. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]** Motor leads shall terminate in the conduit box mounted on the exterior of the motor.

External grease fittings with extended grease leads shall be supplied for lubrication of the fan shaft bearings.

After fabrication, fans shall be prime coated and finish painted. Zinc chromate epoxy primer shall be applied after surfaces are cleaned and degreased. Finish coat shall be air dry acrylic enamel.

ROOF MOUNTED PROPELLER EXHAUST FANS

Furnish and install Greenheck Model PBE and PDE or approved equal ACME, Cook or Carnes roof mounted propeller exhaust fans with capacities as scheduled.

Fans shall be axial type, belt or direct driven as scheduled. Blades shall be die formed and welded to a steel hub. A polished steel fan shaft shall be mounted in permanently lubricated, sealed ball bearing pillow blocks.

The drive frame assembly shall be formed steel. The fan panel shall have prepunched mounting holes, formed flanges with welded corners, and a deep formed venturi. Fans shall bear AMCA ratings seals for air and sound performance.

Round low profile discharge hood shall be fastened to curb with heavy duty full length piano hinge. Fan motor brackets shall mounted down inside roof curb to keep overall unit height as low as possible.

Motors shall be 1750 RPM open dripproof (ODP) type of the horsepower and voltage scheduled. **[Motors 5 hp and larger shall be of the high efficiency, energy efficient type (Refer to Section 23 04 00).]**

Accessories shall include 1/2" mesh birdscreen, prefabricated, insulated, aluminum roof curb, damper tray, disconnect switch, gravity backdraft damper.

CENTRIFUGAL FANS:

A. General: Provide centrifugal fans of the single-width, single-inlet type with either forward or backward curved fan blades and adjustable belt drives.

B. Motors: Provide standard dripproof motors. Provide cast iron housings for motors larger than 10 hp, riveted or spot-weld wheels with steel rims and hub plates.

C. Fan: Blades shall be die cut and die-formed and hubs shall be machined close-grained cast iron.

Steel housings shall have lock-seam construction with discharge reinforcement and shall be adjustable with continuous inlet collars. Provide weatherproof enclosure for motors and drive, if units are exposed to weather.

D. Manufacturer: The equipment scheduled on the Drawings shall establish design requirements. Equipment that meets or exceeds these standards, manufactured by Buffalo Forge, Carrier, Sturtevant, American Blower, Chicago, Trane, Barry, York, or Clarage will be acceptable.

AXIAL FANS:

A. General: Provide vane-axial and tube-axial fans constructed of heavy gauge welded steel, hot-dipped galvanized after fabrication. Direct drive fans shall have motor support systems acceptable to the Engineer. Lubricated fittings shall be extended to the outside of the fan casing.

B. Fan: Fan blades shall be individually adjustable or controllable pitch. Each fan and fan wheel shall be statically and dynamically balanced and shall be so certified. Fans handling untreated air shall be capable of operating satisfactorily at 0 and 100°F across the fan.

C. Motors: Provide motors having totally-enclosed air over (TEAO) type, a service factor of 1.0, with Class F epoxy-enameled copper windings.

D. Accessories: Provide welded steel inlet and outlet cones, hot-dipped galvanized, and painted after fabrication, for each fan. Where fans are indicated to be controlled pitch, provide pneumatic actuators designed to operate with standard building control air.

E. Manufacturer: The equipment scheduled on the Drawings shall establish the design requirements. Equipment which meets or exceeds these requirements and as manufactured by Buffalo, Sturtevant, Trane, Joy, Woods, or Flakt shall be acceptable.

CEILING EXHAUST FANS:

A. General: Provide direct driven ceiling exhaust fans as scheduled on the Drawings. Fan shall be acoustically insulated and have a maximum sound level rating of 3.6 sones.

B. Motor: Motor shall be suitably grounded and mounted on rubber-in-shear vibration isolators and speeds shall not exceed 1050 rpm.

C. Accessories:

1. Provide totally noise-free, integral backdraft damper, with no metal-to-metal contact.
2. Inlet grille shall be white molded plastic with eggcrate shape and provide 85% free open area.
3. Provide terminal box on the housing with cord, plug, and receptacle inside the housing.

SECTION 23 82 33 - ELECTRIC HEATING COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide duct-mounted electric heating coils as scheduled, specified, and required for the project.

1.3 QUALITY ASSURANCE:

- A. Manufacturers: Provide products complying with these specifications and produced by one of the following:
 - 1. Brausch.
 - 2. Indeeco.
 - 3. Magna-Flow.
 - 4. Redd-i-Heat.
 - 5. Warren.
- B. UL Listing: Coils shall be UL-listed and labeled for zero clearance installation and shall meet all applicable NEC requirements.
- C. SMACNA Compliance: Comply with Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA) standards.
- D. Industry Standards: Comply with American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) recommendations pertaining to HVAC coils, except as otherwise indicated.

1.4 SUBMITTALS:

- A. Submittals: Shop drawing submittals shall include, but not be limited to , the following:
 - 1. Cut sheets on electric heating coils, clearly marked to show coil sizes, construction, features, and other pertinent information.
 - 2. Coil selections clearly indicating coil sizes, capacities, ratings and pressure drops.
 - 3. Manufacturer's recommended installation instructions.
 - 4. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver duct heaters in factory-fabricated water-resistant wrapping.
- B. Handle duct heaters carefully to avoid damage to tubes, fins, and casing.
- C. Store duct heaters in a clean, dry space, and protect from weather.

PART 2 - PRODUCTS

2.1 ELECTRIC DUCT HEATERS:

- A. General: Provide electric duct heaters with air flow, heating capacities and electrical characteristics as scheduled or shown on the drawings. Heater shall be of a slip-in design and shall be suitable for side or bottom installation in externally insulated or **internally lined** sheetmetal ductwork. The element frame and control panel shall be fabricated of galvanized or aluminized steel.
- B. Heating Elements: Shall be high grade 80/20 nickel chromium with ceramic insulators. Element wires shall not glow when operating at rated capacity. Heaters over 47 inches in any dimension shall have protective screens on the inlet side. Multi-stage heaters shall have their elements split by rows.
- C. Thermal Protection: Heater shall have disc type automatic reset thermal cutouts for primary protection and fusible links for secondary protection.

- D. Control Panel: All unit control and electrical connections shall be installed in an internally insulated factory wired control panel with a hinged and gasketed cover. Control shall include, but not be limited to, fusing for all stages, magnetic contactors, primary and secondary fused control panel transformer, **[PE switches,]** time delay between steps and differential air pressure switch. All components shall be factory wired and only field connections for electric power and **[pneumatic]** controls will be required. **[Settings for PE switches shall be coordinated with the Temperature Controls Subcontractor.]** Control panels for use with lined duct shall be recessed so that the entire surface of the heating elements is in the air stream. An accurate wiring diagram shall be permanently attached to the inside of the control panel door.
- E. Disconnect Switches: Shall be furnished and installed under Division 26.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install electric duct heaters in accordance with the manufacturer's written instructions, the applicable portions of SMACNA and recognized industry practices, to ensure that products serve the intended functions.
- B. Duct Installation: Where heaters are installed in ductwork, a sheet metal channel shall be inserted in the duct on all three sides of the heater to support the heater. Where the heater cross-sectional area is less than the duct cross-sectional area an equalizing grid shall be installed on 3 sides of the heater per SMACNA guidelines. Transitions shall not be used. The grid shall be either galvanized wire mesh or a perforated galvanized sheetmetal plate and shall have approximately the same pressure drop as the heater. The grid shall be securely fastened to the duct and heater frame. Where heater cross-sectional is larger than the duct cross-sectional area, the duct shall be transitional to the larger size and then transitioned back, in accordance with SMACNA guidelines.
- C. Cleaning: Clean dust and debris from each coil as it is installed to ensure its cleanliness.

3.2 FIELD QUALITY CONTROL:

- A. Repair: Repair or replace damaged coils as required.

3.3 INSULATION:

- A. General: Non-factory insulated casing shall be insulated as specified in Section 23 07 00.

3.4 IDENTIFICATION:

- A. Refer to Section 23 03 00, for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 82 33

SECTION 23 82 39 – ELECTRIC UNIT HEATERS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

A. Work Included: Provide electric unit heaters and related controls and accessories as shown, scheduled and indicated on the Drawings.

1.3 QUALITY ASSURANCE:

A. Manufacturers: Provide products complying with these specifications and produced by one of the following:

1. Bryant Electric Company.
2. Emerson-Chromalox Division, Emerson Electric Company.
3. I.L.G.
4. Singer.

B. UL-Listing: Provide heaters which are UL-listed.

1.4 SUBMITTALS:

A. Submittals: Shop drawing submittals shall include, but not be limited to, the following:

1. Cut sheets on electric wall heaters, clearly marked to show sizes, ratings, capacities, configuration, construction, features, accessories and other pertinent information.
2. Manufacturers recommended installation instructions.
3. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver unit heaters in factory-fabricated water-resistant wrapping.
- B. Handle unit heaters carefully to avoid damage to material component, enclosure and finish.
- C. Store unit heaters in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 MATERIALS AND COMPONENTS:

A. General: Provide electric unit heater manufacturer's standard materials and components as indicated by published product information, designed and constructed as recommended by the manufacturer and as required for a complete installation.

B. Heating Elements:

1. General: Provide elements of the indicated duty and rated for the indicated capacity consisting of resistance elements in steel sheath with extended fins or in spiral sheath. Provide automatic reset thermal cutoff switch and pressure differential flow switch. Protect the element with a fusible link mixed in series with the heater. Element shall not glow when operating at rated capacity.

2. Electric Heating Capacity: Size element for the indicated cfm and electric input (watts, voltage, and phase).

C. Cabinets:

1. General: Provide cabinets braced and reinforced to provide required stiffness and containing adjustable heating element supports. Provide 1/2" thick, 2 pound density, glass fiber insulation on the interior of the front panel. Phosphatize and paint cabinets inside and out with one coat of baked-on primer. Include discharge air grilles in the cabinet, die-formed with fixed directional louvers or duct connections as indicated on the Drawings. Provide cabinets with removable front panels secured by slide bolt, camlock or Phillips head screws. Fabricate from 16 gauge galvanized steel.

2. Cabinet Accessories: Provide manufacturer's standard accessories of the following types; manufacturer's option if more than one type is indicated for each accessory:

- a. Gaskets between the front panel and the enclosure, manufacturer's standard gasket material.
- b. Hinged access doors with tamperproof latches.
- c. Removable discharge grilles, steel or aluminum, with single or double deflection or duct connections where indicated on the Drawings.
- d. Removable inlet grilles to match discharge grilles or duct connection where indicated on the Drawings.
- e. Tamperproof panel fasteners consisting of either Allen head machine screws or spanner wrench operating cam fasteners.
- f. Unit levelers
- g. Swivel mounting bracket.

3. Cabinet Finish: Where cabinets are exposed, finish, and color selection shall be submitted to the Engineer for approval.

D. Motors:

1. General: Provide permanent split capacitor motors, resiliently mounted at four points, tap wound with built-in thermal overload protection and of the permanently lubricated-type.

2. Internal Wiring: Provide high temperature, heat resistant wiring in flexible metal conduit from terminal junction box to electrical devices. Provide fuses in motor and control circuit wiring.

3. Devices: Provide the following devices:

- a. Thermally activated fan switch to keep fan motor operating until residual heat is dissipated.
- b. Disconnect switch.
- c. Automatic reset, high limit cutout switch located in discharge air stream.
- d. Magnetic contactor.
- e. Remote-mounted thermostat. Refer to Section 15901, "Pneumatic Temperature Controls", for thermostat standards.

E. Fans:

1. General: Provide propeller fans, balanced statically and dynamically, of the indicated capacity.

Connect fan to a single or double extended motor shaft, with fan, housing and motor-mounted as an integral assembly on a motorboard.

2. Construction:

- a. Wheels: Steel or aluminum.
- b. Housing: Galvanized steel.
- c. Motorboard: Galvanized steel.

F. Controls: Heaters shall be controlled by a concealed, built-in thermostat which is adjustable over a range of 55°F to 85°F and includes a "no-heat" position. Thermostat shall be adjusted by inserting a screwdriver through the front grille. There shall be no evidence of the thermostat visible on the front grille. Heaters shall include a fan delay switch to energize the fan only after residual heat in the elements has been dissipated. A interface relay shall be factory-installed and wired to allow remote interruption of the heater control circuit by the Building Control and Automation System specified under Division 23.

- G. Disconnect Switches: Provide factory-furnished, installed and wired disconnect switch inside the heater cabinet.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. General: Install unit heaters, including components required, in accordance with manufacturer's instructions.
- B. Location: Locate each unit accurately in the position indicated in relation to other work. Position unit with sufficient clearance for normal service and maintenance, including clearance for cabinet removal.
- C. Damaged Fins: Comb out damaged, bent, or crushed fins before closing elements in cabinets.

3.2 TESTING:

- A. General: Test electric unit heaters to demonstrate proper operation. Repair or replace unit heater as required. Retest to demonstrate proper operation.
- B. Replacement: Replace unit heater elements which have heavily damaged fins. Replace accessories which are damaged beyond restoration to an acceptable condition.

3.3 IDENTIFICATION:

- A. Refer to Section 23 03 00, "Basic Materials and Methods", for applicable painting, nameplate, and labeling requirements.

END OF SECTION 23 82 39

SECTION 23 84 13 – STEAM GRID HUMIDIFIERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide a dry steam grid type humidifier that utilizes a steam jacketed distributor.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. ARI 610 - Central System Humidifiers.
 - 2. ARI 630 - Selection, Installation and Servicing of Humidifiers.

1.04 SUBMITTALS

- A. Product Data:
 - 1. Rated capacities, dimensions, duct sizes, piping inlet and outlet dimensions, and electrical service connections and wire sizes, electric nameplate data, electrical and control wiring diagrams.
 - 2. Manufacturer's descriptive literature, operating instructions, installation instructions, clearance requirements, maintenance and parts listing.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to the Project Site under provisions of Division 01 and Division 20.
- B. Protect humidifier and internals from entry of foreign material. Protect pipe openings with the use of temporary caps.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. Armstrong.
- B. DriSteam.
- C. Pure Steam.
- D. Spirax Sarco.

2.03 STEAM GRID HUMIDIFIERS

- A. Provide a dry steam grid type humidifier with the following:
 - 1. Steam jacketed separating chamber.
 - 2. Stainless steel dispersion tube with internal silencing screen, sized by the manufacturer to fit the duct at the required humidifier capacity.
 - 3. Spring electric actuated fully modulating control valve. The control valve is at the normally closed position on loss of electrical power to the actuator.
 - 4. Float and thermostatic type (inverted bucket steam trap if above 15 psi) drain trap, pipeline strainer, and escutcheon plate to completely seal the duct opening.
 - 5. Duct mounted airflow switch option.
 - 6. Condensate return thermostatic switch option set at a temperature of 205 degrees F.
 - 7. Steam strainer.
- B. Humidifiers installed in central air handling units shall be installed on the downstream side of coils or final filter banks.
 - 1. If the humidifier must be located within the air handling unit casing, the humidifier must be shipped to the air handling unit manufacturer to ensure that the humidifier is properly sealed when the low air leakage test is being performed on air handling unit by the manufacturer.
 - 2. The humidifier shall be provided with enough distribution manifolds to limit the steam particle vapor trail to less than three (3) feet at scheduled capacities. The number of distribution manifolds and duct size dimensions determine whether vertical or horizontal mounting configuration will be used.
 - 3. Humidifiers installed in ducts shall be provided with clearance requirements for maintenance.
 - a. The duct section where the humidifier is located shall be constructed of stainless steel material.
 - b. The bottom of the stainless steel duct section shall be pitched to drain off condensed steam. Pipe a stainless steel NPT drain connection welded to the bottom of the duct to the nearest sink or floor drain.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Provide galvanized steel rods to support distribution manifolds and mount in air system plenums.
- D. Connect dry steam humidifiers to steam supply and to condensate piping. Provide gate valve, inlet strainer, and inverted bucket steam trap. Refer to Section 23 22 13 and Section 23 22 30.

END OF SECTION 23 84 13

SECTION 23 84 14 – ELECTRIC STEAM GRID HUMIDIFIERS

PART 1 GENERAL

1.01 SUMMARY

- A. Perform all work required to provide and install electric steam humidifiers with steam jacketed distribution manifolds indicated by the Contract Documents with supplementary items necessary for proper installation.

1.02 RELATED SECTIONS

- A. Section 23 03 00 - Basic Mechanical Materials and Methods.
- B. Section 22 00 00 - Plumbing Piping: Connecting of water and drain services.
- C. Section 23 06 00 - Temperature Control System.

1.03 REFERENCES

- A. ARI 610 - Central System Humidifiers.
- B. ARI 630 - Selection, Installation and Servicing of Humidifiers.

1.04 SUBMITTALS

- A. Submit shop drawings and product data.
- B. Submit manufacturer's installation instructions and operating and maintenance data.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this Section with three years documented experience.
- D. Provide a two year warranty including coverage for humidifier unit except the cylinder.
- E. Provide six extra disposable humidifier cylinders for each unit.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Nortek.
- B. Dri-Steem Humidifiers Co.
- C. DGH System, Inc.
- D. Armstrong Model AMR.
- E. Or accepted substitution.

2.02 STEAM HUMIDIFIERS:

- A. Furnish and install steam humidifiers of the sizes and capacities shown on the Drawings and listed in the equipment schedule. Humidifiers shall be of the multiple dispersion tube, steam injection, dry type wherein entrained condensate is removed from the steam by means of 304 stainless steel, centrifugal type, water/steam separators. Humidifiers shall be designed and catalogued to accomplish 100% absorption within 3' (three feet) downstream of the humidifier when the air is at 95% relative humidity.
- B. Electrode Steam Generating Type Humidifier:
1. CSA certified and UL listed.
 2. Disposable cylinder type.
 3. Electronic capacity control (20% to 100%).
 4. Proportional and integral auto-adaptive control to automatically adapt to incoming water condition.
 5. Alphanumeric LCD display which can indicate system messages, output, control signal input, capacity demand and system configuration.
 6. Keypad to configure, monitor and control humidifier with information messages on LCD display.
 7. Self-diagnostic controls on start-up and during operation shall prevent unsafe operation of the unit.
 8. Solenoid control of supply and drain water.
 9. Automatic self-help feature that can clean obstruction from the drain valve when needed.
 10. Automatic off-season shutdown that will completely drain the cylinder during prolonged off periods and restart automatically on a call for humidity.
 11. Full front access.
 12. Constant Volume Control System: The humidifier shall be controlled by a humidistat, airflow proving switch and high limit control that automatically shuts humidifier down when the humidity level in the duct increases above 80% to 85% RH. Prevents wetting of the ductwork.
 13. Variable Volume Control System: The humidifier shall be controlled by a humidistat, airflow proving switch and modulating high limit control that will automatically reduce the output capacity of the humidifier when the humidity level in the duct increases above 80% to 85% RH. Prevents wetting of ductwork when airflow is decreased.
 14. Dual cylinder units shall have dual control circuits for complete control of each cylinder and safety.
 15. Steam distributor with condensate separator.
 16. Remote message indication capability to indicate normal operation, change cylinder and shutdown shall be standard.

17. Standard of acceptance NORTEC NHMC.
18. Cal-rod heater element electric humidifiers not acceptable.

2.03 ACCESSORIES

- A. Supply and install the following accessories in accordance with the manufacturer's recommendation.
- B. 132-9203: Duct mounted pressure differential switch, for air proving interlock.
- C. 146-9321 through 146-9330: Proportional modulating control. Allows full modulating control of humidifiers by varying signals from control systems supplied by others. Most variable DC voltage, resistance and current signals can be accommodated.
- D. 132-9505: Inline water filter for supply water.
- E. 146-9533: Fill cup extension kit for NH-005 through NH-030. Required when duct static and steam line resistance exceeds standard unit limitations.
- F. 132-8810: Steam hose 7/8 inch ID for ASD and BSD type steam distributors used with NH-005 through NH-030 units.
- G. 132-8840: Condensate return hose 3/8-inch ID. Used with all units.
- H. 146-9525 and 146-9529: Remote service indicator package provides an audible and visual indication remotely from the humidifier when any service code appears.
- I. 146-9522: Low temperature protection. Activates humidifier independent of humidistat if internal temperature falls below set point. Two required for NH-150 and NH-200.
- J. High limit stat to deactivate steam control valve when the high limit is 90 percent or higher.
- K. Provide a FCMS interface card to receive signals from FCMS for controlling the control valve of each humidifier.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's written instructions.
- B. Install in accord with ARI 630.
- C. Provide galvanized steel rods to support distribution manifolds and mount in air system plenums.
- D. Connect outlet of unit to drain piping. Provide gate valve.
- E. Install cold water supply of 1/4-inch type K soft copper tubing with shutoff cock and 7/8 inch drain line. Pipe drain to nearest floor drain ensuring air gap is incorporated per manufacturer's instructions.
- F. Humidifiers to operate only when airflow is proven.

- G. Mount airflow switch and tubing.
- H. Install unit in duct with at least 6'-0" of straight run downstream of humidifier for steam to be absorbed into the air stream. Provide the minimum number of dispersion tubes (manifold) to achieve the complete absorption in the short run.

3.02 COMMISSIONING

- A. Start-up by a factory trained technician.

END OF SECTION 23 84 14