

## SECTION 22 00 10 - PLUMBING GENERAL PROVISIONS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provision of the Contract, including General and Supplementary Conditions and Division 01 specifications, apply to the work specified in this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. This section describes the general provisions for the mechanical and electrical work included in Division 22. This section applies to all sections of Division 22.

#### 1.3 RESPONSIBILITY

- A. The General Contractor shall be responsible for all work included in the Plumbing Division and the delegation of work to Subcontractors shall not relieve him of this responsibility. Subcontractors who perform work under these Sections shall be responsible to the General Contractor. The term "Contractor" is used throughout this Division and shall mean the General Contractor, although the actual performance of the work may be by a Subcontractor.

#### 1.4 REFERENCES AND DEFINITIONS

- A. Following are definitions of terms and expressions used in the Plumbing Sections in addition to those included in Division 01 Sections:
  - 1. Owner: Greater Baltimore Medical Center
  - 2. Architects: Hord Coplan Macht
  - 3. Engineers: Leach Wallace Associates, Inc., Member of WSP
  - 4. Directed - "directed by the Architect"
  - 5. Indicated - "indicated or in Contract Documents"
  - 6. Concealed - "hidden from normal sight"; includes items in shafts, pipe and duct spaces, and above ceilings.
  - 7. Exposed - "not concealed" - Work within Equipment Rooms and all visible (normal sight) work shall be considered exposed".
  - 8. Piping -includes pipes, fittings, valves, hangers and accessories comprising a system.

#### 1.5 STANDARD SPECIFICATION

- A. See General Requirements of the contract.
- B. References to catalogs, standards, codes, specifications, and regulations are the latest edition in effect at date of invitation to bid.

#### 1.6 CODES, REGULATIONS AND PERMITS

- A. Give all necessary notices and obtain all required permits. Pay all fees and other costs, including utility connections or extensions in connection with the work. File all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments having jurisdiction. Obtain all required certificates of inspection and deliver same to the Architect before request for acceptance and final payment for the work.
- B. All materials furnished and all work installed shall comply with the latest rules, regulations, and recommendations of the following bodies:
  - International Building Code (IBC)
  - International Mechanical Code (IMC)
  - International Energy Conservation Code (IECC)
  - National Fire Protection Association (NFPA)
  - National Electrical Code (NEC)
  - National Standard Plumbing Code (NSPC)
  - Fire Prevention Bureaus of Baltimore County and the State of Maryland
  - Baltimore County Department of Health
  - Baltimore Gas and Electric (BGE)

#### 1.7 MATERIALS LIST AND SHOP DRAWINGS

- A. See General Requirements.
- B. Within 15 working days after the award of the contract, the contractor shall submit to the Architect for approval a list of Submittals to be included in the Submittal Schedule in accordance with Section 01 33 00 Submittal Procedures. The list shall include the manufacturers of materials and equipment he proposes to provide. In the event any items of material or equipment contained in the list fail to comply with the specification requirements, such items will be rejected. Rejected items shall be resubmitted within 15 days. Substitution requests shall be submitted in accordance with specified procedure.
- C. After receiving approval of equipment manufacturers and prior to delivery of any material to job site and sufficiently in advance of requirements to allow the Architect ample time for checking, submit for approval dimensioned drawings or cuts showing construction size, arrangement, operating clearances, performance characteristics and capacity of materials and equipment. Each item of equipment proposed shall be a standard catalog product of the approved manufacture.
- D. Samples, drawings, specifications, catalogs, etc., submitted for approval shall be properly labeled indicating specific services for which material or equipment is to be used, section and article number of specifications governing, and Contractor's name, name of job, and date.

- E. Catalogs, pamphlets or other documents submitted to describe items on which approval is being required shall be specific and identification in catalog, pamphlet, etc., of the item submitted shall be clearly made in ink. Data of a general nature will not be accepted. Any deviations or exceptions taken is the specification by the Contractor shall be so noted.
- F. Any deviations or exceptions taken in the specification by the Contractor shall be so noted.
- G. If material or equipment is installed prior to receipt by the Contractor of approved shop drawings, marked "Approved", "No Exception Taken" or "Make Corrections Noted", the Contractor shall be liable for its removal and replacement at no extra charge to the Owner.
- H. The acceptance of shop drawings shall not relieve the Contractor from his responsibility to furnish material, equipment and systems and to perform work required by the contract documents. Neither the Owner nor the Architect will be responsible for errors or omissions on shop drawings furnished by the Contractor even though such shop drawings containing errors or omissions are inadvertently accepted.
- I. The Contractor is further advised that the Architect will not act as coordinator between suppliers and subcontractors. All required coordination shall be the responsibility of the Contractor.

#### 1.8 CONTRACTOR'S USE OF CAD/Revit FILES

- A. At the Contractor's written request, copies of the Engineer's CAD / Revit files may be made available for Contractor use in connection with the project, subject to following conditions:
  - 1. Submit written request to the Architect Listing the specific drawings the Contractor intends to use. Provide a specific list of submittals that the files will be used in preparing, and the list of names of subcontractors or suppliers.
  - 2. The Contractor shall request in writing the electronic transfer agreement. Prior to transfer of files, the Contractor shall prepare a separate electronic transfer agreement for each subcontractor or supplier who will be using the electronic files.
  - 3. Data contained on the electronic files is part of Leach Wallace Associates (LWA) Member of WSP instruments of service and shall not be used for any purpose other than as a convenience in the preparation of shop drawings for the referenced project. Any other use or reuse will be at the Contractor's sole risk and without liability or legal exposure to LWA.
  - 4. The electronic files are not contract documents. Significant differences may exist between the electronic files and the corresponding hard copy contract documents. Because of the possibility the information and data delivered in machine readable form may be altered, whether inadvertently or otherwise, LWA reserves the right to retain hard copy originals of the electronic documentation delivered to the contractor, in machine readable form, which the original shall be referred to and shall govern in the event of any inconsistency between the two.
  - 5. The use of the electronic files does not relieve the Contractor of their duty to fully comply with the contract documents, including and without limitation, the need to check, confirm, and coordinate all dimensions and details, take field measurements,

verify field conditions and coordinate work with that of other Contractors for the project.

6. All "internal" calculations integral to / performed by the Revit model shall not be utilized for any purpose by the Contractor. This includes, but shall not be limited to, voltage drop calculations, duct static pressure calculations, air system airflow summary calculations, piping system pressure drop calculations, etc.
7. All Revit "families" are the property of LWA and shall not be re-used on any other project for any purpose by the Contractor.

#### 1.9 GUARANTEE

- A. The Contractor guarantees by his acceptance of the Contract that all work provided shall be free from defects in workmanship and materials for a period of one year after date of certification of completion and acceptance of work. Any defects in workmanship, materials or performance which appear within the guarantee period shall be corrected by the Contractor without cost to the Owner within a reasonable time to be specified in notice from the Architect. In default thereof, Owner may have such work done and charge the cost of same to the Contractor.
- B. During the guarantee period, the Contractor shall service all major equipment items provided under this contract, which require outside service agencies. Service shall not include filter replacement, lubrication of motors and bearings or continuation of water and special system chemical treatment after formal acceptance of the systems by the Architect. Prior to the start of guarantee period, the Contractor shall provide the Architect with a schedule of required maintenance operations for each item of equipment. Submit schedule to the Architect for approval. Thereafter, monthly reports shall be submitted to the Owner for describing actual service provided. Forty-eight (48) hours advance notice shall be given to Owner prior to work required under this Section.

#### 1.10 SITE VISIT

- A. Prior to preparing the bid, the plumbing subcontractors shall visit the site and familiarize themselves with all existing conditions. Make all necessary investigations as to locations of existing equipment, ductwork, piping, utilities, etc., work to be removed, and all other matters which can affect the work under the Contract. No additional compensation will be made to the contractor as result of his failure to familiarize himself with the existing conditions under which the work must be performed.

#### 1.11 DRAWINGS

- A. The contract drawings are diagrammatic and indicate the general arrangements of systems and work included in the Contract. Do not scale the drawings. Consult the architectural and structural drawings and details for exact location of structure and equipment; where same are not definitely located, obtain this information from the Architect.

1.12 RECORD DRAWINGS

- A. The Contractor shall keep accurate records of all deviations in work are actually installed from work indicated. One complete set of contract documents shall be available at the construction site for indicating said deviations.
- B. When work is complete, make one (1) complete "As-Built" set of PDF files, certifying the accuracy of each drawing by endorsement and signature thereon and deliver to the Architect who will, after approval, deliver the record drawings to the Owner.
- C. Refer to Section 01 78 39 Project Record Documents for specific requirements.

1.13 OPERATING AND MAINTENANCE INSTRUCTIONS:

- A. Refer to Division 01, Section 01 78 23 for Operation and Maintenance Data requirements.
- B. Refer to Division 01, Section 01 79 00 for Demonstration and Training requirements.

1.14 ELECTRICAL WORK:

- A. Under Division 22 Plumbing, provide the following items of electrical work which shall conform with the applicable requirements of the Electrical Division:
  - 1. Control wiring.
  - 2. Interlock wiring for plumbing equipment.
- B. Under Division 26, 27 or 28, provide:
  - 1. Power wiring complete from source to motor or equipment junction box, including power wiring through motor starters.
  - 2. Motor control centers or motor starter panelboards.
  - 3. All miscellaneous individual motor starters, local wall mounted control devices, unless noted or specified otherwise.
  - 4. All fire alarm interface wiring.

1.15 EQUIPMENT STARTUP AND INITIAL OPERATION

- A. No equipment shall be operated for testing or trial use except after full compliance with the equipment manufacturers' specifications and instructions of the lubrication, alignment direction of rotation, balance, and other applicable considerations.
- B. Particular care shall be taken to see that all equipment is completely assembled and properly lubricated and all grease and oil cases and reservoirs have been filled to the correct level with the recommended lubricant.
- C. It is the Contractor's responsibility to place each item of equipment installed by him in operating condition, including all auxiliaries, piping, wiring, etc., and to start up each unit and check it for performance.

1.16 FIRE PROTECTION:

- A. As minimum, one five-pound CO2 extinguisher shall be provided with each work crew at all times when working within the building.

1.17 SCHEDULE OF WORK:

- A. Refer to project schedule. Specific phasing requirements are to be incorporated into the project schedule; contractor shall coordinate all work included in this division.

1.18 SERVICE AGENCIES:

- A. All plumbing equipment suppliers shall have an established authorized service agency located within the Greater Baltimore Metropolitan area. Within 30 days after award of the Contract, the Contractor shall submit to the Architect for approval a list of manufacturers' material and equipment names, including their respective service agency, he proposes to use. In the event any service agency in the list fails to comply with the specification requirement, such service agency will be rejected.

1.19 SINGULAR NUMBER

- A. Where any device or part of equipment is herein referred to in the singular number (such as "valve"), such reference applies to as many such devices as are required to complete the installation, shown, implied or otherwise, as indicated on the drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. All materials shall be new, the best of their respective kinds, suitable for the conditions and duties imposed on them at the building and shall be of reputable manufacturers. The description, characteristics, and requirements of materials to be used shall be in accordance with qualifying conditions established in the sections following.
- B. Refer to Division 01 for General Requirements.
- C. All component parts of each item of equipment or device shall bear the manufacturers' name plate, giving name of manufacturer, description, size, type, serial or model number, electrical characteristics, etc., in order to facilitate the maintenance or replacement. The name plate of a subcontractor or distributor will not be acceptable. All equipment requiring electrical service shall be U.L. labeled, or if a U.L. label is not available from the manufacturer, the equipment shall be tested by an approved electrical testing company in accordance with NEC, and at no additional cost to the Owner. Submit data indicating compliance with standards prior to installation.

- D. In specifying materials, four general procedures are used. The four classifications are as follows:
1. GROUP 1: When the material or equipment is specified by name of the identifying information and one name brand only is used, it is considered that the use of that particular item is essential to the project, and the Contractor shall base his proposal on the uses of that item.
  2. GROUP 2: When a material or equipment is specified by brand name and other identifying information and two or more brand names are named, it is considered that any one of the brands so named will be performed as desired, and the Contractor shall base his proposal on one of the named brands.
  3. GROUP 3: When the material or equipment is specified with the phrase "...or equal..." after a brand name and other identifying information, it is intended that the brand name is used for the purpose of establishing a minimum acceptable standard of quality and performance and Contractor may base his bid proposal on any item which is in all respects equal to that specified and presents essentially the same appearance, size, operation and performance. The Contractor shall be responsible for coordination of the equal product.
  4. GROUP 4: When material is specified as complying with the requirements of published "Standard Specification" of trade associations, American Society for Testing and Material, government specifications, etc., the Contractor shall base his proposal on any item which can be shown to comply in all respects to the referred to "Standard Specification".
- E. All substitutions shall be submitted in accordance with Section 01 25 00 Substitution Procedures. It is distinctly understood: (1) that the Architect will use his own judgment in determining whether or not any materials, equipment or methods offered in substitution are equal to those specified and will fit within the space available; (2) that the decision of the Architect on all such questions of equality is final; and (3) that all substitutions will be made at no increases in cost to the Owner.
- F. Upon receipt of written approval from the Architect, the Contractor may proceed with substitution providing the Contractor assumes full responsibility for and makes, at his expense, any change or adjustment in construction or connection with any work that may be required by the substitution of such materials, equipment or methods. In the event of any adverse decisions by the Architect, no claim of any sort shall be made or allowed against the Owner.

## 2.2 PIPING SUPPORTS, GENERALLY

- A. Piping shall be run parallel with the lines of the building unless otherwise shown or noted on drawings. The different service pipes, valves, and fittings shall be so installed that after the covering is applied there will not be less than 1/2 inch clear space between the finished covering of parallel adjacent pipes. Hangers on different service lines running parallel with each other and nearly together shall be in line with each other and parallel to the lines of the building. Exact location of electric outlets, piping, ducts, and conduits shall be coordinated among the trades so that there will be no interference between lighting fixtures, piping, ducts, and conduits. Where conflicts between the trades result, they shall be resolved by the Contractor to the Architect's satisfaction and at no expense to the Owner.

- B. In general, hangers shall be spaced so as to prevent sag and permit proper drainage and shall not be spaced more than 10 feet apart unless otherwise indicated herein, Section 22 00 50, or on the drawings. Hangers shall be placed within one foot of each horizontal elbow.
- C. Vertical runs of pipe and conduit not over 15 feet long shall be supported by hangers placed not over one foot from the elbows on the connecting horizontal runs. Vertical runs of pipe and conduit over 15 feet long but not over 60 feet long and not over 6 inches in size shall be supported on heavy steel clamps. Clamps shall be bolted tightly around the pipes and conduits and shall rest securely on the building structure without blocking.
- D. Hangers shall be of manufacturers hereinafter specified in Section 22 00 50. Unless otherwise specified, pipe and conduit hangers and hanger supports shall conform with the following Anvil International figures:
  - 1. Hangers generally shall be Fig. 69, 104, 212, 260 and 300.
  - 2. Hangers Figs. 295 and 212 shall be provided with turnbuckles and eye rods or rods with eye nuts.
  - 3. Turnbuckles shall be Fig. 230 and 114, shall have not less than 1-1/2 inch adjustment, and shall be provided with lockouts.
  - 4. Clamps shall be Fig. 261 or CT-121.
  - 5. Wherever the movement of pipe due to expansion exceeds 3/4 inch per foot of hanger rod length, hangers shall be Figs. 171, 174 and 181.
  - 6. Roller supports shall be adjustable.
  - 7. Concrete inserts shall be Fig. 282 or 281.
- E. On copper pipes, hangers in contact with pipe shall be copper plated.
- F. In lieu of individual hangers, multiple (trapeze) hangers may be used for water pipes having same elevation and slope and for electrical conduits as specified hereinafter:
  - 1. Horizontal members shall consist of 1-1/2 inch by 1-1/2 inch No. 12 gauge, cold formed electro-galvanized dipped channels designed to accept special springheld hardened steel nuts for securing hanger rods and other attachments. Provide metal framing system with applicable fasteners, brackets, fittings, clamps, etc. Two or more such channels may be welded together forming horizontal members of greater strength than single channels. Members shall be Kindorf Series B-995, Unistrut, or approved equal.
  - 2. Each multiple hanger shall be designed to support a load equal to the sum of the weights of the pipes and liquid, the weight of the hanger rods shall be such that the stress at the root of the thread will not be over 10,000 psi at design load, except that no rod shall be smaller than 3/8 inch. The size of the horizontal members shall be such that the maximum stress will not be over 15,000 psi at design load.
  - 3. Horizontal runs of piping along walls, 4 inch and smaller, exposed or concealed, shall be secured to metal framing system as specified herein. Provide appropriate clamps, brackets and similar attachments to secure piping to vertical members in accordance with applicable sections of the specification.
  - 4. On copper pipes in contact with horizontal member, provide rubber strip (Vibra Strip or equal) between hanger attachment and copper pipe.
- G. Hanger attachments shall be suitable for each type of hanger and shall be compatible with the building material to which it is secured. Under no circumstances shall pipe support be secured



to any other mechanical, electrical, or fire protection equipment. Support shall be suspended from building structure only. The type of attachments which shall be used for the various types of building construction encountered are as follows:

1. Steel beams - Fig. 226, or 66 attachments.
  2. Bar joists - Fig. 225, or 60.
  3. Brick or block walls - Fig. 194, 195, 199 or 202 fastened as follows: For light duty, self-drilling anchors in brick and toggle bolts in block; for heavy duty, through bolts with backing plates.
  4. Concrete (Existing) - Phillips "Redhead" or Rawl self-drilling anchors or expansion bolts.
  5. Concrete (New) - Inserts, Fig. 281 or 282. Power driver fasteners may be used for light loading as hereinafter specified.
- H. Welded attachments for securing hangers to piping or to structural steel may be provided in lieu of other attachments specified if prior approval is obtained in the field from the Architect. Welded attachments shall be designed so that the fiber stress at any point in the weld or attachment will not exceed the fiber stress in the hanger rod. Generally, welding shall not be permitted in finished spaces.
- I. On insulated piping at hangers, provide calcium silicate inserts and shields at each point of support, see Section 22 00 50 and Section 22 07 00.
- J. In no case shall wire or perforated strap be used for pipe or conduit support.
- K. Secure all hangers for piping and ductwork to joist and beams. In no case shall supports be secured to underside of metal or wood deck unless otherwise directed in the field by the Architect. Contractor shall submit details of method of attachments for approval to the Architect.
- L. Refer to Section 22 00 50 for vibration hanger requirements.
- M. Rooftop supports for mechanical piping and equipment shall be constructed of heavy gauge galvanized steel with counter flashing, mitered and welded corner seams, integral base plate and 2x4 pressure treated wood nailer. Supports shall be model es-1, es-2, or es-5, and pipe roller supports shall be model prs-1 as manufactured by the PATE Company or approved equal.
- N. Pipe curb assemblies shall have heavy gauge galvanized steel curb, cap of acrylic clad abs thermoplastic graduated step PVC boots, adjustable stainless-steel clamps and cap fastening screws. Pipe curb shall be model PCA 1, 2, or 5 as manufactured by the Pate Company or approved equal. Contractor shall coordinate exact number and size of openings for piping and conduit penetrations of cap.

## 2.3 SLEEVES AND PLATES

- A. Pipe sleeves through concrete and masonry construction shall be Schedule 40 galvanized steel pipes unless otherwise indicated on the drawings. Openings that cannot be sleeved before slab or wall is poured shall be core drilled. Pipe sleeves through drywall and similar construction shall be sized to pass both pipe and insulation.

- B. Sleeves in existing concrete or masonry walls shall be set and secured with mortar grout and fast drying bitumastic sealant. Caulk the annular space of pipe sleeves with an elastic caulk compound to make installation air and watertight.
- C. Escutcheon plates shall be provided for all exposed pipes and conduits passing through walls, floors, and ceilings in finished areas. Plates shall be chrome plated brass of the split ring type, of size to match the pipe or insulation where installed. Where plates are provided for pipes passing through sleeves which extend above the floor surface, provide deep recessed plates to conceal the pipe sleeves.
- D. Where watertight sleeves are indicated or required to suit the installation, provide Link Seal rubber seals, as manufactured by Thunderline Corporation, between pipes and sleeves.

## 2.4 MOTORS

- A. Provide motors of a size adequate to drive the equipment but in no case less than the size shown or specified. If a motor larger than that specified is required, the Contractor shall bear the expense of changes in foundations, support, wire and conduit connections, circuit protective devices, variable frequency drives, or other affected elements of the system. Each motor shall have sufficient capacity to start and operate the machine it drives without exceeding the motor nameplate rating at the speed specified or at the load which may be obtained by the drive actually provided. Motors shall be rated for continuous duty at 115 percent of rated capacity; base temperature rise on an ambient temperature of 40°C.
- B. Motors for use with variable frequency controllers shall be "Inverter Ready", suitable for variable speed / variable torque applications, designed to withstand a rise time of 0.10 microseconds and a peak voltage of 1600 per NEMA MG1 Section 31.40.4.2.
- C. Motors 1/2 hp and larger shall be 3 phase, Class B, general purpose, squirrel cage, open type, high efficiency, induction motors unless noted otherwise. The rated nominal full load efficiency shall be in accordance with the following schedule when tested in accordance with NEMA test standards when wound for 208 or 480 volts, 60 Hertz, alternating current. Motors smaller than 1/2 hp shall be single phase, open capacitor type in accordance with NEMA standards wound for 115 volts, 60 Hertz, alternating current. Motors 1/6 hp and under may be split phase type.
- D. Motor efficiencies shall comply with the United States Energy and Independence and Security Act (EISA) of 2007 and the latest revision of NEMA Standard MG1 Table 12-2.
- E. Devices (such as: capacitors) or equipment (such as: solid state power factor controllers) when required for power factor correction shall be provided with the motors or item or motor driven equipment. The device shall be mounted and wired to the motor by the project electrical contractor.

## 2.5 DRIP PANS

- A. Where possible to run piping elsewhere, do not run piping directly above electrical (or electronic) work which is sensitive to moisture; otherwise provide drip pans under mechanical piping, sufficient to protect electrical work from leakage. Locate pan immediately below piping, and extend a minimum of 6" on each side of piping and lengthwise 12" beyond equipment protected. Fabricate pans 2" deep of reinforced metal with rolled edges and soldered or welded seams; 16 gauge steel with 2 oz. zinc finish hot dipped after fabrication. Provide 3/4" copper drainage piping, properly discharged, to nearest floor drain, service sink, or as directed in the field.

### PART 3 - EXECUTION

#### 3.1 WORKMANSHIP:

- A. Each subcontractor shall furnish the services of an experienced superintendent who shall be constantly in charge of the installation of the work.
- B. The quality of workmanship required for each trade in the execution of its work shall be the finest and highest obtainable in that trade working with the materials specified. Workmanship shall be satisfactory to the Architect and his decision as to acceptable quality if final.
- C. Contractor shall provide and execute a Quality Control Plan in accordance with section 01 40 00 Quality Requirements.

#### 3.2 EQUIPMENT CONNECTIONS

- A. All equipment shall be installed and connected in accordance with the best engineering practice and in accordance with manufacturer's instructions and recommendations. Auxiliary piping, valves, and electric connections recommended by the manufacturer or required for proper operation shall be provided.

#### 3.3 COMMISSIONING RESPONSIBILITIES

- A. The Contractor, and all the sub-contractors and suppliers within Division 22, shall cooperate with the commissioning agency (CA), and other commissioning team members, to facilitate the successful completion of the commissioning process.
- B. The contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decisions on behalf of the mechanical contractor as they relate to the organization and scheduling of plumbing commissioning. The representative shall ensure communications between Division 22 contractors and suppliers and all other commissioning team members, and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings, and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.

- C. The Contractor, and all sub-contractors and suppliers, shall cooperate with the Commissioning Agency in carrying out the plumbing commissioning process. Refer to Division 01, Section 01 91 13 General Commissioning Requirements for additional information and requirements.

### 3.4 WATERPROOFING

- A. Under no circumstances shall waterproofing be damaged or penetrated. Should conditions arise which indicate such necessity, notify the Architect.

### 3.5 CUTTING AND PATCHING

- A. Cutting and patching associated with the work in the existing structure shall be performed in a neat and workmanlike manner. Existing surfaces which are damaged by the Contractor shall be repaired or provided with new materials and methods similar to existing adjacent work, subject to approval of the Architect. Structural members shall not be cut or penetrated unless otherwise indicated on the drawings. Verify in the field with the Architect. Holes cut through concrete and/or masonry to accommodate new work shall be cut by reciprocating or rotary non-percussive methods. Existing masonry block walls shall be patched with new masonry or gypsum board attached and sealed to both block faces.
- B. See General Conditions.

### 3.6 SURVEYS AND MEASUREMENTS

- A. Base all measurements (both horizontal and vertical) from established benchmarks. All work shall agree with these established lines and levels. Verify all measurements at site and check correctness of same as related to the work. Verify locations of existing utilities and inverts of same prior to the start of any systems shown connecting to utilities.
- B. Should the Contractor discover any discrepancy between actual measurements or conditions and those indicated which prevent following good practice or the intent of the drawings and specifications, he shall notify the Architect and shall not proceed with his work until he has received instruction from the Architect.

### 3.7 HANDLING AND STORAGE OF MATERIALS

- A. Proper and suitable tools, equipment and appliances for the safe and convenient handling and placing of all materials and equipment shall be used. During loading, unloading, and placing, care shall be taken in handling the equipment and materials so that no equipment or materials, including Owner furnished, are damaged.
- B. All plumbing equipment delivered to the job site shall be stored under roof or other approved covering, on pedestals above the ground. All enclosures for equipment shall be weatherproof. Any motors which are not totally enclosed, that are involved in the work, shall be stored in a heated area with a minimum temperature of 50°F. All valves shall be stored under roof on

wood pedestals above ground. All insulation shall be stored under roof or in trailers, adequately protected from the weather. The Contractor shall follow all written instructions and recommendations of the manufacturer and all requirements of the Architect in oiling, protection and maintenance of equipment during storage. It shall be the Contractor's complete responsibility for the storage and care of the equipment and materials.

- C. If any materials and/or equipment are found to be in poor condition at the time of being installed, the Architect may, at his discretion, order the Contractor to furnish and install new equipment at no cost to the Owner.

### 3.8 COOPERATION WITH OTHER TRADES

- A. Exact location of fixtures, clear outs, access ports, piping and valves shall be coordinated with all other trades so that there will be no interference between lighting fixtures, piping, ducts, and conduits. Where conflicts between the trades result, they shall be resolved by the Contractor to the Architect's satisfaction and at no expense to the Owner.
- B. Plumbing trades shall give full cooperation to other trades and shall furnish in writing, with copies to the Architect, all information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay. Exact location of all plumbing equipment in finished spaces shall be coordinated with shop drawings and with elevations indicated on the architectural drawings.

### 3.9 CLEANING AND PAINTING

- A. Thoroughly clean all exposed surfaces of equipment and material and leave in a neat, clean condition ready for painting. Restore and touch-up factory finishes which have been damaged during construction. Finished painting will be performed under another Division.
- B. Miscellaneous requirements include:
  - 1. Provide complete new finish if, in the opinion of the Architect, the factory finishes are severely damaged.
  - 2. Touch up threads of zinc coated screwed pipe with Rustoleum primer and one coat of enamel conforming to painting specification.
  - 3. All exposed hangers, steel supports and miscellaneous components, and cast iron pipe hangers shall be field painted with Rustoleum primer and one coat of enamel conforming to painting specification.
  - 4. All steel support and miscellaneous components shall be painted with Rustoleum primer and one coat of enamel conforming to the painting specification.

### 3.10 ACCESSIBILITY

- A. Locate all equipment which must be serviced, operated or maintained, in fully accessible positions including control valves, balancing valves, and isolation valves. Where required and where directed, provide 14-gauge steel access panels, Milcor or equal, to suit material in which installed. Doors installed in fire rated walls or shafts shall be labeled and shall match rating of

the construction. Door shall be of sufficient size to allow access to all components, except minimum size shall be 24" x 24", unless otherwise noted.

- B. Equipment deemed inaccessible by the Architect shall be reworked by the Contractor at no expense to the Owner. All doors shall have cylinder locks operable from same key. Submit shop drawings for approval.

### 3.11 EQUIPMENT BASES SUPPORTS

- A. All concrete bases, curbs, and supports shall be furnished under the Structural Division unless otherwise indicated. Under this Division provide all other equipment supports required for the plumbing work.
- B. The Contractor shall furnish all required foundation sizes, bolts, washers, sleeves, plates and templates for equipment.
- C. The size of the foundation bolts shall be as recommended by the manufacturer.
- D. The type and size of the supporting channels and supplementary steel shall be determined by the Contractor and shall be of sufficient strength and size to allow only a minimum, deflection in conformance with manufacturer's requirements for loading. Contractor shall submit details for approval to the Architect.

### 3.12 EXCAVATION AND BACKFILL

- A. Excavation: Refer to Section 31 20 00 Earth Moving.
  - 1. Trenches shall be excavated to the necessary width and depth as shown on the drawings. The trench subgrade shall be such as to allow the bedding of the utility with a uniform and continuous bearing on solid, undisturbed earth for the full length of each pipe, except for that portion at the bell ends. The subgrade shall be graded with sufficient accuracy to assure this minimum. The bottom portion of all trenches from the subgrade to a point two feet (2') above the crown or top of the utility shall be as nearly vertical as practicable and at the minimum width.
  - 2. Trenches in fill areas shall not be excavated until embankment construction has been completed to a point at least two feet (2') above the crown or top of the utility being placed.
  - 3. Any part of the bottom of the trench excavated below the specified subgrade shall be back filled, at the Contractor's expense, with bedding materials as hereinafter specified. Whenever wet, or otherwise unstable, subgrade is encountered below the elevation of the original ground surface which existed prior to the time of construction, such soil shall be removed to the depth and extent directed by the Architect and the trench backfilled to the proper grade with bedding material as hereinafter specified. Reimbursement for extra work performed by the Contractor shall be in accordance with General Conditions. Whenever the Architect requires the removal of wet or otherwise unstable subgrade from the fill material previously placed by the Contractor, the cost of all removal of unstable soil, together with backfilling of the trench as herein specified shall be borne by the Contractor.

4. Excavation for manholes and similar structures shall be of sufficient size to leave a minimum of twelve inches (12") and a maximum of twenty-four inches (24") clearance on all sides. Any over-depth excavation shall be filled with concrete as directed and at the expense of the Contractor.
  5. Provide shoring and sheet piling necessary for excavation and for the safety of personnel and property as directed. Unless otherwise directed, the sides of all excavations over four feet (4') deep must be braced. All shoring, bracing, sheet piling, etc., must be solidly installed heavy timber suitable for the purpose. No lumber shall be buried when excavations are backfilled, except by authority of the Architect.
- B. Backfill: Refer to Section 31 20 00 Earth Moving.
1. No backfill and/or bedding and backfill shall be placed until the construction adjacent or the utility to be backfilled has been inspected, tested and approved. Notify the Architect when inspections are required.
  2. Backfill material shall be earth materials only, free from perceptible amounts of wood, debris, or topsoil and shall not contain marble or other elements which tend to keep it in a plastic state. The material shall be free of frost at the time of placement. Backfill for plastic pipes shall be clean sand, free of foreign materials.
  3. Bedding materials, for use where trench subgrade is excavated below specified depth or for use at Contractor's option, shall be crushed stone or gravel, meeting the requirements of a S.R.C. No. 6 aggregate or crusher run S.R.C. CR-6 and shall be free of frost at the time of placing.
  4. Work broken or ruptured by improperly placed backfill shall be removed and replaced by the Contractor at no additional cost to the Owner.
  5. Following inspection as specified above, approved backfill material shall be deposited in the trench with hand shovels, not by means of wheelbarrows, carts, trucks, bulldozers, or similar equipment, in four inch (4") layers and compacted by mechanical tampers until the pipe has a cover of not less than two feet (2'). The remainder of the backfill material shall then be deposited in the trench in eight inch (8") layers and compacted. Any trenches improperly backfilled shall be reopened, then refilled and compacted to the required grade and smoothed off. Backfill shall be placed and tamped to achieve ninety five percent (95%) (Percent of dry weight) compaction.
  6. Field density tests may be required by the Architect in areas where, in his opinion, a question exists with respect to compliance with compaction requirements. These tests will be paid for at standard rates by the Owner, where the test results indicate compliance with the compaction requirements, and by the Contractor where the test results indicate non-compliance with compaction requirements. Density tests shall be performed by the methods specified in A.A.S.H.O. Designation T-147, the Field Determination of Density of Soil-In-Place.

### 3.13 SLEEVES AND PLATES

- A. Sleeves shall be provided by the trade installing the pipe or duct. The sleeves shall be carefully located in advance of the construction of walls and floors where new construction is involved. Provide all cutting and patching necessary to set sleeves which are not placed prior to construction. All cutting and patching necessary to set sleeves which are not placed prior to construction shall be the responsibility of the trade providing the sleeves.

- B. Sleeves shall be provided for all piping and ductwork passing through concrete, masonry, plaster and gypsum wallboard construction. Caulk the annular space of pipe sleeves with an elastic caulking compound to make installation, air, and watertight.
- C. Fasten sleeves securely in the construction so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials being forced into space between pipe and sleeve during construction.
- D. Sleeves required in existing concrete or masonry walls shall be set and secured with mortar grout and fast drying bitumastic sealant.
- E. At all sleeves where objectionable noise can be transmitted, at smoke barriers, at walls above ceilings that extend to underside of the structure of floor above, or at fire rated separations, seal all openings between pipes and corresponding sleeves to prevent sound transmission and to maintain fire rating. Use U.L. approved resilient sealant for penetration seals. Submit method of sealing for approval.
- F. Where pipe motion due to expansion and contraction will occur, provide sleeves of sufficient diameter to permit free movement of pipe. Where sleeves pass insulated pipes, the sleeves shall be large enough to pass the pipe and the insulation. Check construction to determine proper length for various locations; make actual lengths to suit the following:
  - 1. Terminate sleeves flush with walls, partitions and ceilings.
  - 2. Terminate sleeves 2 inches above finished floor in equipment rooms, kitchen and wet floor areas.
  - 3. In all other areas, terminate sleeves 1/2 inch above finished floor unless otherwise noted on the drawings or directed in the field.

### 3.14 ALTERATIONS AND DEMOLITION

- A. All existing piping, equipment and materials which are required to be removed shall be removed. All existing materials and equipment which are removed and are desired by the Owner, or are indicated to remain as the property of the Owner, shall be delivered to him on the premises by the Contractor where directed by the Architect. All other materials and equipment which are removed shall become the property of the Contractor and shall be promptly removed by him from the premises.
- B. Remove all indicated mechanical work by hand as far as possible. Power-driven equipment shall be used as a last resort and shall not be employed without consent of the Owner. Schedule all demolition work to the satisfaction of the Owner. The Contractor shall execute the removal work as quietly as practicable to avoid unnecessary disturbances to occupied areas.
- C. Existing conditions, i.e. ductwork, piping, equipment, etc, may be obtained from available record drawings and are not warranted to be complete or correct. Contractor shall verify exact location of all ductwork, piping, etc, in the field prior to starting any work.



- D. Existing pipe sizes noted on the available record drawings are for the convenience of the Contractor only. Contractor shall verify sizes in the field.
- E. Existing piping no longer required to remain in service shall be disconnected and removed back to service mains, including existing piping hangers and supports. Existing pipe indicated or required to remain in service shall be capped.
- F. Existing piping that remains concealed, buried, or otherwise contained in or below the remaining slabs and walls shall be capped, plugged, or otherwise sealed. All pipes shall be cut so that their capped or plugged ends will be far enough behind finished surfaces to allow for the installation of the normal thickness of finished material.
- G. When existing plumbing work is removed, all related pipes, valves, and materials shall also be removed.
- H. When the work specified herein connects to existing piping, the Contractor shall perform all necessary alterations, cutting, or fitting of the existing work as may be necessary or required to make satisfactory connections between the new and existing work and to leave the completed work in a finished and workmanlike condition, to the entire satisfaction of the Architect.
- I. When the work specified herein or under other divisions of the contract necessitates relocation of existing plumbing equipment or piping, the Contractor shall perform all work and make all necessary changes to existing work as may be required to leave the completed work in a finished and workmanlike condition, to the entire satisfaction of the Architect, and at no additional cost to the Owner.
- J. Existing mechanical equipment and piping affected by removal or new work installation and required to remain in service shall be reinstalled or supported as required in accordance with new work specification. All work shall be completed to the Architect's satisfaction and at no additional cost to the Owner.
- K. Valve off or disconnect live services as required for removal work.
- L. Refer to drawings for additional requirements.

### 3.15 FLASHING

- A. Openings for pipes through waterproofed floors and roof areas shall be flashed. Vent pipes shall be flashed with 4 lb. sheet lead 24 inches square. Flashing shall be extended up around vents, which shall terminate not less than 12 inches above roof, and shall be fastened under vent caps.
- B. Refer to Architectural drawings and specification for additional roof flashing requirements.

### 3.16 COORDINATED DRAWINGS

- A. Prior to installation of plumbing work in all areas including exposed areas (spaces without ceilings), the Contractor shall prepare completely coordinated layout drawings indicating the coordinated work of all trades involved. The drawings shall be a sheet size similar to the contract drawings. All work shall be to scale minimum  $\frac{1}{4}" = 1' - 0"$ . The drawings shall include all work shown on the drawings, including equipment (air handling units, pumps, etc.), variable frequency controllers, ATC control panels, terminal units, ductwork, air devices, dampers, piping including sprinkler and plumbing, valves, light fixtures, electrical cable trays, raceways, and conduits 1" and larger.
- B. All trades shall be responsible for the preparation of the coordinated layout drawings. Each trade shall provide written certification that the coordinated drawings have accurately incorporated their work and that all conflicts are resolved or a solution is proposed on the drawings. The Contractor shall schedule the trades accordingly and shall provide final certification that all coordination has been completed.
- C. No work shall be installed prior to the Architect's approval of the drawings. The Contractor shall submit for approval of the Architect within 15 days after the award of the contract a schedule of proposed building areas to be grouped for coordination. Upon approval of the schedule, work may commence in areas of the building upon approval of that area's coordinated drawings prior to approval of another area.

### 3.17 CLOSE OUT PROCEDURES

- A. Refer to Section 01 77 00 close out procedures for specific requirements.

END OF SECTION 22 00 10

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## SECTION 22 00 50 - PLUMBING BASIC MATERIALS AND METHODS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to the work specified in this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. This section includes requirements for plumbing equipment, materials and procedures which are common to more than one section of Division 22 and which are general in nature and use. This section applies to all sections of Division 22.
- B. The requirements of Section 22 00 10, Plumbing General Provisions, shall apply to all work specified under this section.

#### 1.3 LEAD CONTENT

- A. All plumbing products, materials of construction, and joining methods used in the installation or repair of plumbing intended to dispense water for human consumption shall be in compliance with the United States Safe Drinking Water Act and shall meet the limit of weighted average lead content as set forth in NSF/ANSI 372. All such products shall also meet the lead leaching requirements of NSF/ANSI 372.

#### 1.4 SUBMITTALS

- A. Submit shop drawings for all items of materials specified in this section in accordance with Section 22 00 10 and Division 01 requirements.
- B. At a minimum, manufacturer's product data shall include specifications, installation instructions and general recommendations for each type of material required. Include data substantiating that proposed materials comply with specified requirements for each type.
- C. Before ordering any Tag and ID materials conduct a coordination meeting with facility O&M staff and CxA to coordinate with existing hospital nomenclature. Submit a proposed tagging method for each valve, device, fixture and equipment incorporating unique ID's and room numbers for approval.

## 1.5 TESTS AND ADJUSTMENTS

- A. The Contractor shall furnish labor, instruments, equipment, and materials required to perform tests prescribed in the sections describing the various systems.
- B. Replace or repair defects found during inspection or test with new materials. Caulking of welded joints, screwed joints, cracks, or holes is not acceptable. Correct leaks in screwed fittings by remaking joints. In welded systems leaks in joints shall be cutout and re-welded. Repeat tests after defects have been eliminated.
- C. Where reasonable doubt exists as to a system's ability to comply with contract requirements, perform any reasonable test required by the Architect.
- D. Make static pressure tests and prove to the satisfaction of the Architect that the piping is tight before pipes are concealed or insulated. Tests shall be provided as hereinafter specified.
- E. Use test instruments for accuracy by an approved laboratory or by the instrument manufacturer and furnish certificates showing degree of accuracy to the Architect when requested. Make calibration histories for each instrument available for examination.
- F. Where gauges, thermometers and other instruments which are to be left permanently installed are used for tests, do not install until just prior to the tests to avoid possible changes in calibration.

## PART 2 - PRODUCTS

### 2.1 HANGERS

- A. Refer to Section 22 00 10.
- B. Hangers and accessories shall be Anvil International, Fee and Mason, Modern, National, or B-Line of the types specified in Section 22 00 10.
- C. It shall be the responsibility of the Contractor to provide an adequate pipe suspension system in accordance with recognized engineering practices, using standard, commercially accepted pipe hangers and suspension equipment.
- D. The design of all hangers and support shall be in accordance with the provision of the current issue of MSS-SP-58 document developed as a standard by the Manufacturers' Standardization Society.
- E. Hangers for steel pipe, except as noted otherwise shall be spaced at least every ten (10') feet. Hangers for cast iron pipe shall be provided at each joint. Hangers for copper pipe shall be placed at least every eight (8') feet, except pipes 1½ inch and smaller and shall have hangers at six (6') foot intervals. Polyvinyl chloride pipe (PVC) shall have hangers at four (4) foot intervals.

- F. Where concentrated loads of valves, fittings and similar items occur, or if recommended by the piping manufacturer, closer hanger spacing will be necessary.
- G. Generally, hangers shall be clevis type, standard weight.
- H. Vibration hangers shall be provided as specified.
- I. On insulated piping systems, provide Pipe Shields, Inc., Model CS-CW or approved equal hanger shields at each point of support. Diameter of hanger shield shall match thickness of the insulation. In lieu of, provide wood dowel insert and minimum twenty-gauge protection shield at each point of support. Diameter of insert and shield shall match thickness of the insulation and encompass 50% of insulation surface. On cold systems seal insert vapor tight with appropriate coating.
- J. Hangers in direct contact with copper piping systems shall be copper plated.

## 2.2 IDENTIFICATION AND EQUIPMENT TAGS

- A. All control devices, i.e. panels, switches, starters, push button stations, controls etc., shall be clearly identified as to their function and the equipment controlled.
- B. All plumbing equipment shall be marked to clearly identify said equipment and space or duty they serve.
- C. Plumbing equipment herein specified shall be identified using engraved laminated black and white phenolic legend plates. Letters shall be minimum, 3/4" high white on surrounding black. Plates shall be mounted by means of sheet metal screws. Submit nameplate list to Architect for approval.
- D. Plumbing equipment, valves, etc., concealed above ceiling shall be identified as to location using clear plastic self-adhesive tape with black lettering, applied to ceiling tile "T" bars. Submit nameplate list to Architect for approval.
- E. Piping shall be identified with colored, pre-rolled, semirigid plastic labels as manufactured by Seton, Marking Services, Inc., or approved equal. For indoor installations, labels shall be Seton "Set Mark" system. For outdoor installations, labels shall be Seton "Ultra Mark" system. Labels shall be set around pipes with a field installed high strength cement around pipes with a field installed high strength cement compound applied along their longitudinal edge. Labels shall be placed around the piping or insulation every forty feet (40) and with one (1) label on each pipe in rooms smaller than fifteen feet (15). Medical gas and vacuum piping shall be labeled every twenty (20) feet. A label shall be placed at every major valve and at least six feet (6) from exit or entrance to an item of equipment. At Contractor's option, piping concealed above suspended ceilings only, may be identified by stenciling with black paint and taped color bands in accordance with the coding system herein specified.
  - 1. Labels shall be provided in accordance with the following table with color coding and stencil designations as indicated:

#### SIZE OF LETTERS

Outside Diameter of Pipe (Inches)	Length of Color Field (Inches)	Size of Letters (Inches)
3/4" to 1-1/4"	8"	1/2"
1-1/2" to 2"	8"	3/4"
2-1/2" to 6"	12"	1-1/4"
8" to 10"	24"	2-1/2"
Over 10"	32"	3-1/2"

2. Color coding and stencil designations shall be as follows:

<u>Service</u>	<u>Color</u>	<u>Stencil Designation</u>
Domestic cold water	Green	Domestic cold water
Domestic hot water	Yellow	Domestic hot water
Domestic hot water recirculating	Yellow	Hot water recirculating
Sanitary	Brown	Sanitary sewer
Storm water	Brown	Storm water
Secondary storm water	Brown	Secondary Storm water
Vent	Brown	Vent
Condensate drain	Brown	Drain water
Oxygen	Green	Oxygen
Vacuum	White	Vacuum

- F. In addition to labeling as specified hereinbefore, all piping exposed within the central plant, penthouses, exposed within mechanical and electrical equipment spaces, utility spaces, janitor's closets, and piping elsewhere "exposed" as defined in Section 22 00 10, shall have full color coding, painted in a color identifying system type. Paint colors shall conform to the following schedule:

Domestic cold water (including makeup water)	Green
Domestic hot water (all temperatures)	Yellow
Domestic hot water recirculating	Yellow
Sanitary	Brown
Storm water	Brown
Secondary storm	Brown

water	
Vent	Brown
Condensate drain	Brown
Oxygen	Green
Vacuum	White

- G. All valves, except as specified below, shall be provided with colored plastic or brass valve tags with stamped-in numbers. Tags shall be secured to valve wheels with metal chain. Stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent, need not be so equipped. Care shall be exercised in selecting valve numbers to be prepared on tracing linen showing locations, details of arrangements, etc., of all service and control valves indicating identity and function. One black line print of each drawing shall be mounted under glass where directed. Valve tags shall be Seton or approved equal minimum 1-1/2" round tags with white characters describing system and valve designation. Submit valve number list for approval.

## 2.3 PIPE, FITTINGS, AND JOINTS

### A. General

1. Piping materials shall conform to state and local code requirements. Pressurized piping systems shall conform to American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME) B31.9, "Code for Pressure Piping, Building Services Piping". High-pressure piping shall conform to ANSI/ASME Section I, B31.1, "Code for Pressure Piping, Power Piping".
2. Quality and weight of materials shall comply with requirements of applicable American Society of Testing Materials (ASTM), ANSI, ASME, and Cast Iron Soil Pipe Institute (CISPI) standards. ASTM number and wall thickness shall be indicated on each pipe length
3. Provide pipe and fittings for systems as hereinafter specified. All references to codes shall apply to the latest year. Grooved products may be as manufactured by Victaulic or Grinnell. All piping and fittings shall be made in America.

### B. Pipe Materials

1. Sanitary Drainage
  - a. Underground
    - 1) Cast Iron Soil Pipe
      - a) All sizes - service weight ASTM A74-98, fittings shall be cast iron service weight ASTM A74-98 fitting joints shall be pre-molded rubber gaskets, Tyler Pipe Industries, Ty-Seal Or Multiple Seal, polyvinyl chloride gaskets manufactured in accordance with ASTM C 564.
  - b. Above ground, within the building
    - 1) No-hub Cast Iron Soil Pipe
      - a) All sizes - service weight, ASTM A888-98 fittings shall be no-hub cast iron, fitting joints shall be no-hub neoprene gasket and stainless steel corrugated shield, four band, Anaco-Husky series 4000 meeting ASTM C 1540, C564, and CISPI 310.



- c. Sanitary piping from supply and waste boxes to mains or risers shall be Enfield or Charlotte Chemdrain.
- 2. Sanitary Piping Above Food Preparation And/Or Food Service Areas Only:
  - a. Copper drainage tubing
    - 1) All sizes - DWV, ASTM B306, fittings shall be wrought copper and bronze drainage fittings ANSI B16.29 with soldered joints: Taramet Sterling "lead free" solder or equivalent.
- 3. Vent Piping:
  - a. No-hub cast iron soil pipe
    - a) All sizes - service weight, fittings shall be no-hub cast iron, fitting joints shall be no-hub neoprene gasket and stainless steel corrugated shield, Anaco-Husky series 4000 meeting ASTM C 1540, C564, and CISPI 310.
  - b. Copper drainage tubing (Above food preparation and/or food service areas)
    - 1) All sizes - DWV, ASTM B306, fittings shall be wrought copper and bronze drainage fittings ANSI B16.29 with soldered joints: Taramet Sterling "lead free" solder or equivalent.
- 4. Storm Water Drainage
  - a. Underground
    - 1) Cast iron soil pipe
      - a) All sizes - service weight, ASTM A74-98, fitting shall be cast iron service weight ASTM A74-98, fitting joints shall be pre-molded rubber gaskets, Tyler Pipe Industries, Ty-seal or Multiple Seal, polyvinyl chloride gaskets manufactured in accordance with ASTM-C-564-98.
  - b. Above ground, within the building
    - 1) No-hub cast iron soil-pipe
      - a) All sizes - service weight, fittings shall be no-hub cast iron, fitting joints shall be no-hub neoprene gasket and stainless steel corrugated shield, Anaco-Husky series 4000 meeting ASTM C 1540, C564, and CISPI 310.
- 5. Air Conditioning Condensate and Equipment Drainage:
  - a. Copper drainage tubing
    - 1) All sizes - DWV, ASTM B306 with wrought copper and bronze drainage fittings, ANSI B16-29 with soldered joints: Taramet Sterling "lead free" solder or equivalent.
- 6. Domestic Cold Water:
  - a. Domestic cold water above ground, 2-1/2" and larger
    - 1) Seamless copper water tube
      - a) All sizes - ASTM B88, Type L hard tempered with wrought copper solder joint fittings, rated for 150 lbs. (water) ANSI B16.22. Press Fitting: Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22 and

- performance criteria of IAPMO PS 117. Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer. Press ends shall have SC (Smart Connect) feature design (leakage path).
- b. Domestic cold water above ground, 2" and smaller
    - 1) Seamless copper water tube
      - a) All sizes - ASTM B88, Type L hard tempered with wrought copper solder joint fittings, rated for 150 lbs. (water) ANSI B16.22 with soldered joints Taramet Sterling "lead free" solder or equivalent.
      - b) Alternate fitting - Press Fitting: Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22 and performance criteria of IAPMO PS 117. Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer. Press ends shall have SC (Smart Connect) feature design (leakage path).
7. Domestic Hot Water and Hot Water Recirculation:
- a. Seamless copper water tube
    - 1) All sizes - ASTM B88, Type L hard tempered with wrought copper solder joint fittings, 150 lbs. (water) ANSI B16.22 with soldered joints: Taramet Sterling "lead free" solder or equivalent. Galvanized steel pipe is not permitted.
      - a) Alternate fitting - Press Fitting: Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22 and performance criteria of IAPMO PS 117. Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer. Press ends shall have SC (Smart Connect) feature design (leakage path).
8. Medical Gas and Vacuum Piping:
- a. Seamless copper tube
    - 1) All sizes - Type L copper tubing. All solder joint fitting used for connecting copper tubing shall be wrought copper. All copper-to-copper joints shall be made using a copper-phosphorous brazing filler alloy (BCup Series) without flux. Dissimilar metals such as copper and brass shall be joined using an appropriate flux with either a copper-phosphorous (BCup Series) or a silver (BAg Series) brazing filler alloy. Tubing shall be joined by brazing or silver soldering, without flux, by a compound having a melting point exceeding 1,050oF. A low flow (0.5 scfm) nitrogen purge should be continuously conducted through the tubing during brazing to prevent the formation of copper oxide scale on inner walls.
      - a) Alternate fitting – Axially Swaged Brass Fitting: Axially swaged, elastic strain preload fittings providing metal to metal seal having pressure and temperature ratings not less than that of a brazed joint and when complete are permanent and non-separable. Manufacturer shall be Lokring Medical Gas Fittings with fitting material 360 brass as per ASTM B16.

9. Foundation Drains

- a. Foundation drainage piping shall be slotted corrugated polyethylene (PE) tubing according to ASTM F-405 with maximum 1/8" slot width for at least the lower 120 degree sector with similar fittings.

- b. Geotextile requirements are as follows:

Grab strength lbs. (ASTM D4632)	120 lbs. (min.)
Elongation (%) (ASTM 4833)	N/A
Puncture Strength (ASTM 3786)	60 lbs. (min.)
Burst Strength (ASTM 3786)	225 PSI (min.)
Trapezoidal tear (ASTM D-5741)	50 lbs. (min.)
Apparent opening size	<#70 US Standard Sieve Minimum
Permittivity (ASTM D4491)	1.01/sec. (min.)
Ultraviolet degradation at 150 hrs (ASTM D4355)	70% strength retained

2.4 VALVES

A. General

1. Valves shall be provided where indicated on drawings and as herein specified.
2. Valves shall be placed in such a manner as to be easily accessible for handwheel operation and stuffing maintenance.
3. Valves in piping where shown and where listed herein:
  - a. To balance flows in plumbing piping systems.
  - b. To isolate all items of equipment.
  - c. To isolate branch lines and riser at mains.
4. Valve pipe connections shall be screw, solder, welded, flanged, press fit or Victaulic as required to be consistent with other parts of the piping system.
5. Where piping or equipment may subsequently need to be removed, provide valves with bodies having integral flanges or full lugs drilled and tapped to hold valve in place so that downstream piping or equipment can be disconnected and replaced with blank-off plate while valve is still in service.
6. Install valves in accessible locations and adjust for smooth and easy operation.
7. Valves for equipment and controls shall be installed full size of pipe before reducing size to make connection.

8. Where there is no interference, shut-off valves shall be installed with handwheel down on horizontal runs of pipe to prevent accumulation of foreign matter in packer between seats at closing end of wedge.
- B. Balancing Valves
1. Provide balancing valves where indicated and required to balance water flow through the piping system. For pipe sizes 2 1/2" and larger provide separate balancing valve and flow meter fitting.
  2. Balancing valve for system piping shall be DeZurik, Homestead or approved equal eccentric plug valve as follows: flanged 2-1/2" and larger, with Fluorinated Hydrocarbon filler in a PTFE U-ring (packing) and CIIR or EPDM plugs and Chloro-Isobutene Isoprene plug facing suitable for -20 to 250°F continuous operation. Valves shall have lever actuators with adjustable memory stop. For 2" and smaller, provide combination balancing and flow fitting with screwed ends as manufactured by Nexus, Tour & Anderson, or approved equal.
- C. Ball Valves
1. Ball valves shall be used in lieu of gate valves in all domestic water piping systems size 3" and smaller for shut-off service. Ball valves shall be Apollo.
  2. For valves up to 2½" in size the body and bonnet shall be ASTM B62 bronze. For valves 3" body shall be bronze or brass. Ball shall be Type 316 stainless steel. Stem shall be stainless steel. Seats shall be TFE.
  3. Stem shall be blowout proof and externally adjustable to compensate for wear. Valve shall be equipped with vinyl covered lever handle which shall indicate position of ball orifice and shall have stops for fully open and closed position. Construction shall be such that power actuator can be used. Ball opening shall be full pipe size.
  4. Valve shall be suitable for flow in either direction and shall be rated 150 psig SWP and 600 psi non-shock WOG.
  5. Valve shall be so constructed with three-piece cast bronze bodies, full port design, with adjustable stem packing. Valves used for domestic service shall be lead free.
  6. Ball valves used for balancing shall have adjustable memory stop. For use in insulated piping systems provide 2" extended handles of non-thermal conductive material.
- D. Drain Valves
1. Drain valves shall be ball valves with hose end connections and shall be provided at low points of all piping system and where indicated or required, 3/4" minimum. Provide Nibco Series 585-70-HC or approved equal. Valve shall be rated for 125 lbs.
- E. Valve Schedule
1. Unless otherwise specified, valves shall be Grinnell, Stockham, Crane, Jenkins, or Nibco equal to the Nibco figure numbers indicated herein:
  2. Domestic Hot and Cold Water Systems:
    - a. Check - Solder end S-413
    - b. Check valves at pump discharge shall be in line spring loaded or swing design with weight or lever and spring.

## 2.5 PIPE ANCHORS

- A. All pipe lines shall be anchored where specified herein, indicated on drawings and where required to prevent uncontrolled movement. Anchors shall be constructed of steel and plates, assembled by bolting or welding and secured to the building structure by means of clamps or welding. Structural members shall not be cut or drilled. Anchors shall prevent both axial and lateral movement of the lines. Anchor vertical pipes by means of clamps welded to pipe and secured to wall or floor construction. Submit details of anchors to Architect for approval.
- B. Anchor piping adjacent to flexible pipe connectors to prevent connector from expanding against its restraining bolts and also to keep the pipe on both sides of the connector in alignment.

## 2.6 EXPANSION (WATER SYSTEMS)

- A. Where expansion joints are indicated or required, select joints with a traverse of 150 percent of the pipe expansion from the ambient 40°F to the maximum system operating temperature.
- B. All expansion joints shall be suitable for minimum operating pressure and temperature of 150 psi and 300°F, respectively. Expansion joints 2" and larger shall have flanged ends, except when installed in copper pipe systems.
- C. Submit for approval manufacturer's shop drawings of each expansion joint provided depicting length of pipe, location of anchors and guides, calculated expansion offset and type of joint employed.
- D. Expansion joints shall be as herein specified:
  - 1. Flexible Ball Type - Barco Type N of Series 600.
  - 2. Corrugated Type - Flexonics "Low-Corr" joints for pipes 3" and larger. Flexonics Model H or HB for pipes smaller than 3".
  - 3. Slip Type - Flexonics "Slip Pakt" with anchor base.
  - 4. Loop expansion joints.
    - a. Provide flexible hose expansion loop(s) as indicated on the contract drawings or as required to accommodate any thermal expansion, contraction or seismic movement of the piping system.
    - b. Flexible hose expansion loops shall be manufactured complete with two parallel sections of corrugated metal house, compatible braid, 180 degree return bend, with inlet and outlet connections. Field fabricated loops shall not be acceptable.
    - c. Flexible loops shall be capable of movement in the  $\pm X$ ,  $\pm Y$ , and  $\pm Z$  planes.
    - d. Flexible hose expansion loops shall impart no thrust loads to system support, anchors or building structure.
    - e. For flammable liquid or gas service up to 4", flexible expansion loops shall be CSA / AGA certified.
    - f. All flexible hose expansion loops shall be manufactured in accordance with the documented manufacturers weld procedure specifications. The procedure qualification record shall be used to document the execution of this procedure and shall follow the general "guidelines" of ASME Section IX. Each individual welder shall conform to the in-house procedure qualification record and be

qualified prior to each production lot. The testing of each individual welder shall be documented in a welding procedure qualification record.

- g. Flexible hose expansion loops to be Metraloop as manufactured by The Metraflex Company or approved equal.
- h. Corrugated Hose shall be stainless steel with 304 stainless steel braid.
- i. Fittings Materials of construction and end fitting type shall be consistent with pipe material and equipment/ pipe connection fittings. Copper fittings shall not be attached to stainless steel hose.
- j. Flexible hose expansion loops shall have a factory supplied, hanger / support lug located at the bottom of the 180 degree return.
- k. Flexible hose expansion loop(s) shall be furnished with a plugged FPT to be used for a drain or air release vent, and hanger lug at the bottom of the 180 degree return.

## 2.7 PIPE GUIDES

- A. Provide pipe guides where indicated on drawings or where required for proper installation of expansion loop. Limit use of guides with expansion loop to point shown or where required to prevent buckling of pipe whether indicated or not.
- B. Do not use pipe guides as pipe supports.
- C. Provide factory made cast semi-steel or other heavy fabricated steel consisting of bolted two-section outer cylinder and base with a two-section guiding spider welded or bolted tight to the pipe of sufficient size to clear pipe insulation and long enough to prevent over-travel of spider in cylinder. Furnish a guide sleeve of a length not less than the length of pipe expansion plus the spider length.

## 2.8 VIBRATION ISOLATION

- A. General:
  - 1. Plumbing equipment and associated piping shall be mounted on vibration isolators as specified and required to minimize transmission of vibrations and structure-borne noise to building structure or spaces.
  - 2. Select vibration isolating units for the lowest operating speed of equipment so designed that natural frequency of equipment and base mass is not less than 1.5 times the lowest operating frequency of the moving equipment but not a multiple or harmonic of the base frequency. Furnish vibration isolation producing a uniform loading and deflection even when equipment weight is not evenly distributed, and be stable during starting and stopping of equipment without excessive traverse and eccentric movement of equipment.
  - 3. The installed vibration isolation system for each floor or ceiling mounted item of equipment shall have a maximum lateral motion under equipment start up and shut down conditions of 1/4". Motions in excess shall be restrained by approved spring type mountings.

4. All electrical connections, drain connections, etc., made to equipment which rests on vibration isolators, shall be sufficiently flexible to permit the equipment to be properly isolated.
5. The type of isolation, base, and minimum static deflection shall be as required for each specific equipment application, but no case less than that specified herein when supported on a solid concrete structural slab having a thickness of not less than 4". If vibration isolators with a deflection greater than the minimum specified are required to meet the noise criteria for the adjacent spaces, suitable isolation systems shall be submitted. Should vibration isolators installed for the equipment prove inadequate to prevent transmission of equipment vibrations to the building structure or limit equipment vibration originated noises in the building spaces to acceptable levels, the isolators shall be replaced with units having the largest deflection that can be practicably installed.
6. Spring and combination rail and spring isolation supports where designated in the schedule are indicated for equipment structurally built or supported on a rigid structural steel frame suitable for these types of isolation. Where these types of isolation are not suitable for the equipment construction or operation, the equipment shall be mounted on a structural steel base as herein specified.
7. Equipment affected by wind pressure or with operating weight different from installed weight shall have built-in adjustable vertical stops to prevent rising of equipment when weight is removed. Equipment containing liquid shall have vertical stops.
8. Inertia bases shall consist of a steel reinforced concrete slab cast into a welded structural steel channel frame. Frame shall be fabricated of sufficient strength to prevent distortion of any type during construction, and when the equipment is in operation. Equipment anchor bolts with bottom plates and pipe sleeves shall be preset. One-half inch steel reinforcing bars shall be placed on 6" center both ways in a layer 1-1/2" above the bottom of the base; bars shall extend inside channel frame flanges not less than 1".
9. Where required due to equipment configuration, the inertia block construction shall change and the concrete thickness shall increase as necessary for the proper mounting of the equipment. The weight of the inertia base shall be equal to or greater than the weight of the equipment supported. Additional weight necessary to reduce vibration or motion caused by the equipment's unbalanced forces to less the 1/32" movement shall be provided when necessary.
10. Each electric motor shall be mounted on the same foundation as the driven machine. Piping connections including strainers at pumps shall be supported on the same foundation as the pumps.
11. All exterior vibration isolation shall be hot dip galvanized.

B. Vibration Isolation Equipment

1. All isolation equipment shall be Mason Industries, Kinetics Noise Control, Vibration Eliminator, Amber/Booth, or Korfund equal to the following Mason Industries products:
  - a. Type II Mounting - Stable Springs. Mason Type SLF.
  - b. Type IV Hanger - combination spring and double deflection neoprene element. Mason Type 30N.
  - c. Type V Hanger - similar to Type IV with elevation holding device. Mason Type PC30N.

- d. Type VII Hose - Flexible pipe connector. Mason Type SFEJ or approved equal, with control rods.
- e. Type IX Base - structural steel base form for floating concrete base. Provide base of sufficient length to support pipes as indicated. Mason Type K.

C. Application of Isolation Equipment:

Item	Type	Deflection
Piping – hangers within 50 ft. of isolated equipment	V	1.50"
Piping – First two hangers near non-isolated equipment	IV	0.75"
Flexible Pump Connectors	VII	---

2.9 TEST PLUGS

- A. Pressure and temperature test plugs where indicated or required shall be 1/4" npt fittings, suitable to receive either a 1/8" OD temperature or pressure probe. Fittings shall be solid brass with Nardel valve core, fitted with a color-coded marked cap with gasket. The entire assembly shall be rated at 1000 psig. Provide two (2) pressure gauge adapters and two (2) 5" stem thermometers, 0°F to 220°F and 20°F to 130°F range. Plugs shall be as manufactured by Peterson Equipment Company, Inc., Richardson, Texas or Sisco plugs.

PART 3 - EXECUTION

3.1 CLEANING

- A. After completion of installation, thoroughly clean dirt, rust, loose scale, oils and grease, and other foreign matter from metal and insulated surfaces, painted or unpainted, specified under Division 22 of the specification.
- B. Clean all systems piping thoroughly of grease, metal shavings, welding beads, or other refuse. Flush piping by use of portable pump or separate water supply to prevent damage to existing or new system pumps. Before cleaning closed systems, all equipment shall be isolated by closing inlet and outlet valves and opening the by-pass valves. The system shall be filled with sufficient detergent and dispersant added to remove all dirt, oil, and grease. System shall be circulated for at least 48 hours after which a drain valve at the lowest point shall be opened and allowed to bleed while the system continues to circulate. Bleeding shall continue until water runs clear and all detergent is removed. A sample of the water shall be tested and, if PH exceeds the PH of the make-up water, draining shall be resumed. After flushing, clean strainers of debris and close by-passes. Remove dirty water filters and install new water filters. Turn over replacement bag filters to Owner. Refill and vent water systems being sure to add water after venting to completely fill system.



### 3.2 PIPING INSTALLATION

- A. Install piping without undue stress or strain in locations shown and run parallel to the lines of the building, except to grade them as specified in a neat and workmanlike manner using a minimum of fittings. Provide such fittings, valves, and accessories as may be required to meet the conditions of the installation. Contractor shall inform himself fully regarding any peculiarities and limitations of space available for installation of material under each section of specifications. Install piping to suit necessities of clearance with ducts, conduits, structure, and other work, and so as not to interfere with any passages or doorways and allow sufficient head room at all places. Use proper reducing fittings for changing piping sizes.
- B. Do not install piping through transformer vaults, elevator equipment rooms or other electrical or electronic equipment spaces. Do not route piping over electrical-distribution panels.
- C. Cut pipes accurately to measurements established in the field in a neat and workmanlike manner without damage or without forcing or springing. Perform cutting by means of an approved type of mechanical cutter of the wheel type where practicable. Ream pipe after cutting to remove all burrs.
- D. Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Carefully investigate the architectural, structural, and existing conditions affecting the work, and arrange such work accordingly, providing such fittings, and accessories as may be required to meet such conditions.
- E. Install unions and flanges where shown and on each side of all pieces of equipment and other similar items, and in such a manner that the unions or flanges can be readily disconnected. Do not place any union or flange in a location which will be inaccessible after completion of the project. Unions or flanges for servicing and disconnect are not required in installations using grooved joint couplings.
- F. Unions in steel pipe 2-1/2" and smaller for water service, shall be 250 lb. malleable iron brass, seat type. Use 150 lb. forged steel flanges for piping 3" and larger. Gaskets shall be 1/8" thick rated for 150 psi service at 250°F. Unions in copper pipe 2" and smaller shall be wrought copper with red bronze ring nut. Use 150 lb. ASME copper flanges for piping 2-1/2" and larger.
- G. Use dielectric unions or couplings at all junctions of copper or brass piping and fittings with ferrous material to prevent electrolysis and galvanic corrosion.
- H. Joints between dissimilar piping material shall be made with appropriate adapters in accordance with the respective manufacturer's printed instruction and recommendations.
- I. Use reducing fittings, eccentric where required to prevent pocketing of air and water or both, to make changes in pipe sizes.
- J. Grade pipe minimum 1" in 40 feet to low points, unless otherwise specified or indicated. Provide drain valves at all low points.

- K. All piping shall be so installed so that it will in no way be distorted or strained by expansion or contraction. Except as noted, all expansion and contraction shall be taken up by means of swing joints, loops, bends or long offsets. Swing joints made up with at least three fittings shall be provided in branches from mains to runouts. Size loops for the total pipe expansion without cold springing, but field cold spring one-half the pipe expansion corrected for ambient temperature.
- L. Provide a fitting restraint system at the base of each no hub storm water piping riser 4" and larger in size, and extending vertically 3 floors or greater, with all base ells 45° to 90°. Fitting restraint system shall be Holdrite No Hub Series 117, or approved equal.
- M. Coat all uninsulated piping underground (except cast or ductile iron piping or polymer) with two layers of asphaltic paint, one layer of six-mil polyethylene film, one layer of 15-pound asphaltic felt. Spirally wrap all pipe lines embedded in concrete with two layers of 30-pound asphaltic felt.
- N. Underground piping shall be installed in a continuous enclosure to protect the pipe from damage during backfilling. The enclosure shall be split or otherwise provide access at the joints during visual inspection and leak testing. Backfill shall be clean and compacted so as to protect and uniformly support the piping. A continuous tape or marker placed immediately above the enclosure shall clearly identify the pipeline by specific name. In addition, a continuous warning means shall be provided above the pipeline at approximately one-half the depth of bury. Where underground piping is installed through a wall sleeve, the ends of sleeve shall be sealed to prevent the entrance of ground water. Piping underground within buildings or embedded in concrete floors or walls shall be installed in a continuous conduit.
- O. Grooved joints shall be installed in accordance with the manufacturer's latest published instructions. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service. Gaskets shall be molded and produced by the grooved coupling manufacturer. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove. Grooved coupling manufacturer's factory trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, application of groove, and installation of grooved piping products. Factory trained representative shall periodically visit the jobsite to ensure best practices in grooved product installation are being followed. Contractor shall remove and replace any improperly installed products.

### 3.3 LOOP EXPANSION JOINTS

- A. Install and guide per manufacturer's installation instructions and Mechanical Contractors Association of America "Guidelines for Quality Piping Installations".
- B. Flexible hose expansion loop return fitting shall be supported to allow movement.

### 3.4 WORKMANSHIP

- A. Cut pipes accurately to measurement established at structure. Install pipes without springing or forcing.
- B. Clear windows, doors, and other openings with all pipes. Arrange pipes to permit expansion and contractions without misalignment or damage.
- C. During construction all openings in piping and equipment shall be closed with caps or plugs to keep out all foreign matter indicated.
- D. All piping in finished spaces shall be run concealed unless otherwise indicated.

### 3.5 PHASING

- A. The contractor shall schedule phasing to minimize the disruption of existing patient services. This phasing is essential to ensure a safe environment in patient care areas. Phasing shall include assurance for clean to dirty airflow, emergency procedures, criteria for interruption of protection, construction of roof surfaces, written notification of interruptions, and communication authority. Procedures must be developed for noise and vibration that will affect patients, and planned accordingly. The renovation areas shall be isolated from the occupied areas during construction using airtight barriers, and exhaust airflow shall be sufficient to maintain negative air pressure in the construction zone.

### 3.6 SLEEVES AND PLATES

- A. Refer to Section 22 00 10.

### 3.7 FLOW METER FITTINGS

- A. Locate and arrange piping, both upstream and downstream of fitting to conform to the manufacturer's published literature.
- B. When flow is measured in horizontal pipe, locate the connection nipples at or slightly above the horizontal centerline of the pipe to minimize the entrance of gases and impurities.
- C. Provide each fitting with an integral tab, or a metal tag or a stainless steel wire, extending outside the pipe covering, and stamp or print in a plainly visible position the manufacturer's name and address; the model number of the meter to which it is to be connected; the name, number or location of the equipment served; the specified rate of flow and the multiplier (including unity, where applicable) to be applied to the meter reading.
- D. Provide fittings with shut-off valves and with quick connecting hose fittings for portable meters.

### 3.8 TESTS

- A. The following tests shall be conducted by the Contractor and all piping shall be proven tight in the presence of the Architect or his representative. Notify Architect prior to tests. These tests shall be conducted before any insulation is installed and any insulation installed prior to test shall be removed. Provide all equipment and labor required. Tests shall be at least four hours in duration. Piping may be tested in sections as approved by the Architect. Tests shall be specified herein.
- B. Domestic water piping shall be hydrostatically tested to 150 psig. All openings in the water piping shall be plugged throughout the system, or portion thereof, filled with water, and tested with a pump to a pressure of 150 psig.
- C. Sterilization
  - 1. Domestic water system piping shall be disinfected after tests in accordance with State or District Health Department requirements. Before placing the systems in service, contractor shall engage a qualified service organization to sterilize the new water lines in accordance with the following procedure:
  - 2. Through a 3/4" hose connection in the main entering the building, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 PPM. Plumbing contractor shall provide plumbing connections and power for pumping chlorine into the system.
  - 3. Proceed upstream from the point of chlorine application opening all faucets and taps until chlorine is detected. Close faucets and taps when chlorine is evident.
  - 4. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 PPM chlorine, retain this water in the system for three (3) hours. CAUTION: Over-concentration of chlorine and more than three (3) hours of retention may result in damage to piping system.
  - 5. At the end of the retention period, no less than 100 PPM of chlorine shall be present at the extreme end of the system.
  - 6. Proceed to open all faucets and taps and thoroughly flush all new lines until the chlorine residual in the water is less than 1.0 PPM.
  - 7. Obtain representative water sample from the system for analysis by a recognized bacteriological laboratory.
  - 8. If the sample tested for coliform organisms is negative, a letter and laboratory report shall be submitted by the service organization to the contractor, certifying successful completion of the sterilization.
  - 9. If any samples tested indicate the presence of coliform organisms, the entire sterilization procedure shall be repeated.
- D. The sanitary, storm water, condensate drain and miscellaneous drain systems shall be hydrostatically tested. Tests shall be as required by code and as a minimum shall comprise the plugging of all openings in the line, filling the system (or portion thereof) with water until all joints are proven tight. Piping shall be tested with a minimum head of 10 feet of water.
- E. All pressure piping systems, unless otherwise specified herein, shall be filled with water and thoroughly flushed clean of foreign matter after erection and before connection of equipment.

- F. Testing and verification of medical gas and vacuum systems shall be required for all new work and modifications to existing medical gas and vacuum piping as indicated on the documents. Testing and verification of medical gas and vacuum system shall be as follows:
1. The medical gas and vacuum systems, including all source equipment, valving, alarms and station outlets shall be evaluated and certified for mechanical and therapeutic function as defined in the National Fire Protection Assn. (NFPA) ii, Compressed Gas Assn. (CGA) and The Facility Guidelines Institute: "Guidelines For Design and Construction of Health Care Facilities", 2018 Edition. This testing shall be performed by an agency independent of the facility, contractor, or their suppliers. The Agency shall specialize in medical facilities and shall be able to demonstrate experience and expertise in medical gas and vacuum installations and meet the requirements of ASSE 6030.
  2. The Agency shall provide to the facility full documentation of the following:
  3. That all medical gas and vacuum systems as constructed follow the guidelines of the NFPA 99, regarding the placement and applicability of valves, alarms, and source equipment. The Agency shall not be responsible for evaluation of Contractor's technique in such elements as routing and hangers except as per paragraphs 3.8.F.4, 3.8.F.6, and 3.8.F.7 below.
  4. That no cross connections exist in the pipeline as constructed. Documentation shall include examination of the outflow of each station outlet, following a mechanical cross connection procedure as specified by NFPA 99. Additionally, each system outflow shall be examined with an appropriate analyzer and the concentrations shall be documented. All medical gas and vacuum systems shall be included in the mechanical examination.
  5. That all station outlets are delivering gas at a pressure and flow consistent with anticipated needs, as these shall be defined by responsible authorities within the facility, but in no case to be below CGA or NFPA guidelines.
  6. That the pipeline is free of debris, including liquid.
  7. That all station outlets are functional.
  8. That delivered gas is as pure as required by applicable CGA/USP requirements for breathing gas. Samples shall be taken from such station outlets as shall be agreed by the facility and the verification agency. In no case in testing for hydrocarbons shall the number of samplings be fewer than two (2), one from source and one from such station outlets as will provide the gas has traversed the greatest length of pipeline. Samples shall be evaluated against CGA/USP requirements for human use and compared to one another.
  9. That all reserve source equipment and its control equipment is in place and is operational.
  10. That all valves are functional. The control zones shall be documented without regard to plans. This documentation shall be compared to the as-built plans, and all discrepancies between the actual installation and the plans shall be reported to the facility.
  11. That all alarms are functioning and are set in accordance with NFPA 99. The surveillance areas of each shall be documented and compared as in paragraph 3.8.G.10 above.
  12. That medical air is dry. The examination shall consist of a dewpoint taken at source and most distant station outlet of each lateral branch. Temperatures and pressures affecting the dryness shall be documented.
  13. The documentation shall be provided by an independent testing agency approved by the Engineer, and shall contain all of the above information as well as the verification. These documents shall become part of the permanent records of the facility.

Verification shall be issued upon successful completion of all specified tests. The Contractor shall not be released from his contractual obligation until verification is obtained.

END OF SECTION 22 00 50

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## SECTION 22 05 33 - HEAT TRACING FOR PLUMBING PIPING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to the work specified in this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Section includes heat tracing for plumbing piping.

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with Section 22 00 50.
  - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
  - 2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
  - 3. Include diagrams for power, signal, and control wiring.

### PART 2 - PRODUCTS

#### 2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

- A. Subject to compliance with requirements, provide products by one of the following:
  - 1. Thermon Americas Inc.
  - 2. Chromalox, Inc.
  - 3. Raychem; Tyco Thermal Controls.
- B. Comply with IEEE 515.1.
- C. Heating Element: Pair of parallel No. 16 AWG, tinned, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, non-heating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.
- D. Electrical Insulating Jacket: Flame-retardant polyolefin.



- E. Cable Cover: Tinned-copper braid and polyolefin outer jacket with ultraviolet inhibitor.
- F. Maximum Operating Temperature (Power On): 150 degrees F.
- G. Maximum Exposure Temperature (Power Off): 185 degrees F.
- H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- I. The heater shall be:
  - 1. Volts: 277
  - 2. Phase: 1
  - 3. Hertz: 60

## 2.2 CONTROLS

- A. Local Thermostat with Ground Fault Protection and Alarm Relay, Tracon Model GPT-130 or equal. Coordinate controls with Division 23.
  - 1. Remote bulb unit with adjustable temperature range set to activate heat trace at 40 deg F.
  - 2. Two-pole contactor switches up to 30 AMP heater loads.
  - 3. Integral 30ma GFEP.
  - 4. Enclosure shall be corrosion-resistant polycarbonate and NEMA 4X rated.
  - 5. The system shall sense ambient temperature in the general area of the traced pipe and turn heat tracing on when outside temperature is below 40 deg F and turn the heat tracing off when outside temperature is above 42 deg F.
  - 6. Remote interface provided via alarm relay. The system shall self test and alarm for no power, ground fault condition, GFEP function test failure, and damaged thermistor.

## 2.3 ACCESSORIES

- A. Provide cable installation accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
- B. Warning Labels: Vinyl-based and installed on the thermal insulation weather barrier. In accordance with the NEC, electrically heated pipelines and vessels are to be clearly identified "at frequent intervals along the pipeline or vessel". Caution labels should be placed at 10'-20' intervals or as required by local code.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

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

### 3.2 INSTALLATION

- A. The Division 26 contractor shall be responsible for power wiring and terminations between the electrical power system, the controls, and the heat trace power connections kits. The Division 22 contractor shall be responsible for control wiring, and conduit if required. The Division 22 contractor shall, in conjunction with Division 23, provide system layout drawing including cable, control location, sensors, and power connection points. Divisions will be required to coordinate with each other to meet specified installation requirements.

- B. Install electric heating cable across expansion, construction, and control joints according to manufacturer's written instructions; use cable-protection conduit and slack cable to allow movement without damage to cable.

- C. Install controls per manufacturer's written instruction.

- D. Electric Heating-Cable Installation for Freeze Protection for Piping:

1. Install electric heating cables after piping has been tested and before insulation is installed.
2. Install electric heating cables according to IEEE 515.1.
3. Install insulation over piping with electric cables according to Section 22 07 00 "Plumbing Systems Insulation."
4. Install warning tape on piping insulation where piping is equipped with electric heating cables.

- E. Set field-adjustable switches and circuit-breaker trip ranges by Division 26.

### 3.3 CONNECTIONS

- A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

- B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

### 3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.

3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
  - B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.
  - C. Cables will be considered defective if they do not pass tests and inspections.
  - D. Prepare test and inspection reports.
- 3.5 PROTECTION
- A. Protect installed heating cables, including non-heating leads, from damage during construction.
  - B. Remove and replace damaged heat-tracing cables.

END OF SECTION 22 05 33

## SECTION 22 05 93 - TESTING, ADJUSTING AND BALANCING FOR PLUMBING SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to the work specified in this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. This section includes all labor and materials necessary to adjust, balance and test performance in accordance with design criteria and the equipment and components of systems included in Division 22 as follows:
  - 1. Compressed Air / Vacuum Systems
  - 2. Water Distribution
  - 3. Equipment Performance

#### 1.3 QUALIFICATIONS

- A. All work shall be performed under direct supervision of a qualified engineer. All instruments used shall be accurately calibrated and maintained in good working order. If requested, calibration tests of equipment to be used shall be performed in the presence of the Engineer or Owner's Representative.
- B. Work included in this section shall be performed by a pre-approved air and water balancing firm, who shall test, adjust, and balance the air and water systems for this project in accordance with NEBB or AABC Standard Procedures. Submit the name and qualifications of the air balance firm for approval within thirty (30) days after award of contract.
- C. Qualifications shall include the name of the technician that will be assigned to this project. The technician's qualifications shall be included and shall include successfully completed projects of similar size and complexity, references, and formal training.
- D. Acceptable air and water balance firms for this project shall include American Testing, Inc. and Baumgartner Incorporated.
- E. If the Contractor fails to submit the name of an acceptable agency within the specified time, the Architect will select a firm to accomplish the work, and the selection shall be binding at no additional cost to the Owner.

- F. All work shall be performed under direct supervision of a qualified engineer. All instruments used shall be accurately calibrated and maintained in good working order. If requested, calibration tests of equipment to be used shall be performed in the presence of the Engineer.

#### 1.4 TEST REPORT

- A. The balancing agency shall prepare a written report which shall include diagrams and description of procedures together with all recorded test data. The report shall be submitted in bound volumes for a permanent record. Submit four (4) copies of report. A set of contract drawings shall also be submitted. Drawings shall have each air flow fitting, pump, and traverse location identified in red ink by a number which shall match identification numbers utilized in the balancing report. Commissioning checklists and functional performance test sheets shall be included in a separate section of final testing, balancing and commissioning report.
- B. Provide preliminary, informal reports to CxA as systems are completed which also note any found deficiencies. Provide preliminary reports before Functional Performance Testing.
- C. Reports shall be submitted in accordance with requirements of Section 01 33 00 Submittal procedures.

#### 1.5 TEST PROCEDURE

- A. Systems may be tested in increments when approved by the Engineer.
- B. When testing and balancing involve the building temperature control systems, cooperate with the temperature control subcontractor to achieve the desired results. All setpoints shall be documented and included with test report.
- C. At the time of the final inspection, recheck in the presence and at the request of the Engineer not to exceed ten percent (10%) of the previously recorded readings from the certified report selected at random from the log by the Engineer.
- D. Permanently mark the settings of valves, dampers, and other adjustment devices so that adjustment can be restored if disturbed at any time. Do not permanently mark devices before final acceptance.
- E. Perform all tests in accordance with NEBB or AABC standard procedures. Any deviation from same must be approved by the Engineer.
- F. Should the basic system or any of its components fail to meet contract requirements, and thereby make the testing and balancing work invalid, notify the Engineer and stop the tests until such time that the failure is corrected.

## PART 2 - PRODUCTS

## 2.1 TESTING INSTRUMENTS

- A. Use instruments of equal or better quality than those described in the technical portions of Associated Air Balance Council National Standards for Testing and Balancing, Heating, Ventilating and Air Conditioning Systems, Fifth Edition, 1989.
- B. Instruments used for balancing air and water systems must have been calibrated within a period of six (6) months prior to balancing. Submit serial numbers, and dates of calibration of all instruments to be used prior to the start of work.
- C. Instrumentation shall include, as a minimum, the following items of equipment:
  - 1. Pressure gauges and fittings.
  - 2. Dry bulb and wet bulb thermometers.
  - 3. Contact pyrometer.
  - 4. Portable flow meter and, if required, orifice plates.
  - 5. Pitot tube and manometers.
  - 6. Alnor Velometer with attachments.
  - 7. Amprobe.
  - 8. Tachometer.
  - 9. Data Loggers

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. Within fifteen (15) days of receipt of notice to proceed, review plans and specifications of systems to be tested and balanced to confirm that the arrangement, instrumentation and balancing devices will permit the system to be balanced and tested in the manner described in this section and report to the Engineer any devices which need to be added or any phase of the design which needs to be modified to permit the fulfillment of this contract.
- B. Conduct balancing and testing in accordance with technical portions of the Associated Air Balancing Council--"National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems, Fifth Edition, 1989". Test procedures not in accordance or not described in the standards, i.e., shall be approved by the Engineer in writing.
- C. Provide all labor, testing equipment, and materials required to conduct tests and balance systems.
- D. System shall be operated at least four (4) hours after stabilized operating conditions have been established before conducting capacity tests. Capacity and performance tests of equipment and systems shall be performed only after balancing is complete.

### 3.2 WATER DISTRIBUTION SYSTEMS

- A. After the fluid piping system, including strainers, have been cleaned and controls are functioning as required under other sections of Division 22, adjust balancing devices installed for this purpose in accordance with the NEBB or AABC technical procedures to obtain the specified fluid flow or heat transfer rate.
- B. Use reading from system flow fittings, when installed, to determine flow quantity. Where fittings are not installed, determine liquid flow by measuring water pressure drop through devices with known Cv or pressure drop at specific flow rates. Use flow meter compatible with the type of fittings installed.
- C. Where liquid flow balancing cannot be accomplished due to system deficiencies such as excessive or lack of pumping head, inadequately sized motors, pressure drops not determinable or similar problems, prepare a list of such deficiencies and the suggested system modifications and furnish to the Engineer in writing and prior to submission of test report for necessary action.
- D. Specific testing and balancing procedures shall include:
  - 1. Check all air vents for operation. Completely eliminate air from water systems.
  - 2. Set and adjust all pumps for proper delivery rates. Record all pump nameplate information. Record pump flow and motor voltage, amps, and rpm.
  - 3. Set and adjust water flow in all piping system branches and risers including domestic water, and record flow.

### 3.3 EQUIPMENT PERFORMANCE

- A. Conduct performance tests only after the air and water systems have been balanced and the proper flow rates established.
- B. Test and record capacity of heat transfer equipment including all water heaters and heat exchangers. Include the manufacturer's rated capacity at the test operating conditions with the report. Perform tests where possible at design conditions. If tests are not performed under design conditions, interpolate results to determine capacity at full load operating conditions.
- C. Calculate efficiency of pumps by recognized methods using test data.
- D. Perform functional performance tests (FPTS) and document on FPT forms for:
  - 1. Domestic hot water circulation
  - 2. Pumps
  - 3. Other equipment and/or systems as required

### 3.4 COMMISSIONING RESPONSIBILITIES

- A. With respect to Plumbing commissioning, the TAB agency shall
  - 1. Include cost for Plumbing commissioning requirements in the quoted price.
  - 2. Attend commissioning meetings scheduled by the CA prior to, and during, on-site TAB work being done.

3. Submit proposed TAB procedures to the CA and mechanical engineer for review and acceptance.
4. Attend the TAB planning meeting scheduled by the CA. Be prepared to discuss the procedures that shall be followed in testing, adjusting and balancing the Plumbing systems.
5. At completion of the TAB work, submit the final TAB report to the construction manager, with copies to the Owner, CA and mechanical engineer.
6. Participate in verification of the TAB report by the CA for verification or diagnostic purposes. This will consist of repeating a sample of 10% of the measurements contained in the TAB report as directed by the CA.

END OF SECTION 23 05 93



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## SECTION 22 07 00 – PLUMBING SYSTEMS INSULATION

### PART 1 - GENERAL

#### 1.1. RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to the work specified in this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2. SUMMARY

- A. Work included in this section consists of furnishing all labor, equipment, materials and accessories, and performing all operations required, for the correct fabrication and installation of thermal insulation applied to the following piping, equipment, and plumbing systems, in accordance with applicable project specifications and drawings:
  - 1. Domestic cold-water piping.
  - 2. Domestic hot-water piping.
  - 3. Domestic recirculating hot-water piping.
  - 4. Sanitary waste piping.
  - 5. Storm-water piping.
  - 6. Roof drains and rainwater leaders.
  - 7. Supplies and drains for handicap-accessible lavatories and sinks.
  - 8. Plumbing equipment.
  - 9. Air conditioning condensate and equipment drain piping.
- B. The requirements of Section 22 00 10, Plumbing General Provisions, shall apply to the work specified under this Section.

#### 1.3. DEFINITIONS

- A. The k factor means the number of British thermal units of heat transmitted per (sq. ft.) Fahrenheit temperature difference through a material with flat, parallel sides one inch (1") apart. The material shall be tested and rated according to ASTM Test Method C-177.
- B. The term "Mineral Fiber" as defined above specifications includes fibers manufactured of glass, rock or slag processed from a molten state, with or without binder.
- C. Unless otherwise specified, the term concealed, as used in this specification, shall include all furred spaces, accessible pipe and duct shafts, and spaces above suspended ceilings.

- D. Unless otherwise specified, the word exposed shall refer to all work other than "concealed" work.

#### 1.4. REFERENCES

- A. Thermal insulation materials shall meet the property requirements of one or more of the following American Society for Testing of Materials (ASTM) specifications as applicable to the specific product or use:
  - 1. ASTM C 533-07: "Specification for Calcium Silicate Block and Pipe Thermal Insulation"
  - 2. ASTM C547: "Standard Specification for Mineral Fiber Pipe Insulation"
  - 3. ASTM C553 "Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications"
  - 4. ASTM C585 "Standard Practice for Inner and Outer Diameters or Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System)"
  - 5. ASTM C 612 "Standard Specification for Mineral Fiber Block and Board Thermal Insulation"
  - 6. ASTM C 795 "Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel"
  - 7. ASTM C 1126-04: "Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation"
  - 8. ASTM C 1136 "Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation"
  - 9. ASTM C 1290 "Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts"
  - 10. ASTM G-21 "Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi" (fungi resistance section only)
  - 11. ASTM G 22 "Practice for Determining Resistance of Plastics to Bacterial (bacteria resistance section only)

#### 1.5. SYSTEM PERFORMANCE

- A. Insulation materials furnished and installed hereunder should meet the minimum economic insulation thickness requirements of the North American Insulation Manufacturers' Association (NAIMA) to ensure cost-effective energy conservation performance. Alternatively, materials should meet the minimum thickness requirements of National Voluntary Consensus Standard 90.1, "Energy Standard for Buildings Except Low Rise Residential Buildings" of the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor. In no case shall the insulation thickness be less than that specified herein.
- B. Insulation materials furnished and installed hereunder shall meet the fire hazard requirement of any one of the following specifications:
  - 1. American Society of Testing of Materials ASTM E 84
  - 2. Underwriters' Laboratories, Inc. UL 723
  - 3. National Fire Protection Association NFPA 255

1.6. FIRE RESISTANCE

- A. Except for materials which are subsequently exempted, all materials used as part of the thermal insulation shall have a fire hazard rating not to exceed twenty-five (25) for flame spread and fifty (50) for fuel contributed and smoke developed.
- B. Test factory assembled materials as assemblies.
- C. Determine ratings by the Standard Method of Test for Surface Burning Characteristics of Building Materials, ASTM E-84 or NFPA No. 255.
- D. The following will be required to establish that fire hazard ratings for materials proposed for use do not exceed those specified: (1) label or listing by Underwriter's Laboratories, Inc., (2) certified test report from an approved testing laboratory.
- E. The following materials are exempt from the foregoing Fire Resistant Rating:
  - 1. Jackets of canvas, PVC and nylon.
  - 2. Polyurethane, polystyrene, cork and flexible, closed-cellular insulation.
  - 3. Nylon anchors for securing insulation to equipment.
  - 4. Factory pre-molded one (1) piece PVC fitting and valve covers

1.7. QUALIFICATIONS

- A. Materials submitted shall be standard products of a manufacturer who has been engaged in the production of the products for not less than three (3) years.
- B. The installing sub-contractor shall have at least five (5) years of successful installation experience on projects with similar insulation products.

1.8. QUALITY ASSURANCE

- A. Insulation materials and accessories furnished and installed hereunder shall, where required, be accompanied by manufacturers' current submittal or data sheets showing compliance with applicable specifications listed in Section 1.4 above.
- B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.

1.9. SUBMITTALS

- A. Provide shop drawings in accordance with Section 22 00 10 and the General Requirements which shall include all insulation, jackets, finishes, corner beads, etc. Shop drawings shall additionally describe each system or component to be insulated, insulation type and thickness, and method of installation.

1.10. DELIVERY AND STORAGE OF MATERIALS

- A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.
- B. The contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The contractor shall also use all means necessary to protect work and materials installed by other trades.
- C. If any insulation material has become wet because of transit or job site exposure to moisture or water, the contractor shall not install such material, and shall remove it from the job site. An exception may be allowed in cases where the contractor is able to demonstrate that wet insulation when fully dried out (either before installation, or afterward following exposure to system operating temperatures) will provide installed performance that is equivalent in all respects to new, completely dry insulation. In such cases, consult the insulation manufacturer for technical assistance.

1.11. COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 00 50 and Section 22 00 10.
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.12. SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1. GENERAL

- A. All insulating materials, including adhesives, jackets and coatings, to be used on the project must be delivered to the building in the manufacturer's unopened container and must bear the manufacturer, brand and description of material.

- B. After the necessary tests have been conducted to prove the water systems tight, all piping and equipment to be insulated shall be thoroughly cleaned and then covered. Insulation materials shall be the product of Owens Corning, Knauf, Manville or Armstrong equal to the products specified herein.
- C. Molded pipe insulations shall be manufactured to meet ASTM C 585 and ASTM C 547.

## 2.2. TYPES OF INSULATION

- A. Refer to insulation type schedule on drawings.

## 2.3. ADHESIVES, SEALERS AND COATINGS

- A. Provide all adhesives, sealers, vapor barrier coatings etc., compatible with the material to which they are applied. They shall not corrode, soften or otherwise attack such material in either the wet or dry state and must be suitable for the service temperatures.
- B. Any cement, sealer or coating used shall be resistant to vermin and mold and shall be durable. It shall not discolor on aging; and where applied on the final surface of the insulation, it shall be light in color and be capable of being painted.
- C. Adhesives, coatings and compounds shall be equal to the following:
  - 1. Vapor barrier adhesive for sealing joints on pipe insulation - Foster 85-75.
  - 2. Insulating cement - Owens Corning No. 110

## 2.4. FITTINGS AND VALVE COVERS

- A. Pipe fittings and valves shall be insulated with Owens Corning PVC pre-molded one (1) piece PVC insulated fitting cover and factory pre-cut insulation. Fittings shall have edges of one (1) piece cover sealed with Owens Corning vapor barrier pressure sensitive tape.

## 2.5. PROTECTIVE SHIELDING GUARDS:

- A. Protective Shielding Pipe Covers
  - 1. Plastic wraps for covering plumbing fixture. Hot- and cold-water supplies and trap and drain piping as manufactured by Truebro, McGuire Manufacturing, Zurn Industries or Insul-Tect. Comply with Americans with Disabilities Act (ADA) requirements.
- B. Protective Shielding Piping Enclosures
  - 1. Plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping as manufactured by Truebro, Zurn Industries or equal. Comply with ADA requirements.

## 2.6. METALLIC COMPONENTS

- A. Staples shall be outward clinching type of Type 304 or Type 316 stainless steel.
- B. Bands shall be galvanized steel, aluminum, brass, or nickel-copper alloy, of three-quarter inch (3/4") nominal width. The band thickness, exclusive of coating, shall be not less than five thousandths inch (0.005") for steel and nickel copper alloy, seven thousandths inch (0.007") for aluminum, and one hundredth inch (0.01") for brass.
- C. Wire shall be 14-gauge, nickel-copper alloy or copper clad steel, or 16-gauge, soft annealed, galvanized steel.
- D. Wire netting used for exposed surfaces of insulation that is to be cement finished shall be 22-gauge, one- inch (1") galvanized mesh, with continuous 26-gauge galvanized steel corner beads having two and one-half inch (2-1/2") wings.
- E. All exterior piping shall be additionally covered with a sixteen mil (16 mil) (0.4mm) embossed aluminum or stainless-steel weatherproof jacket. Jacketing shall be Childers Lock-on type with factory applied poly kraft moisture barrier. Jackets are to be fabricated with continuous Z-lock on the longitudinal seam and sections shall be joined with factory fabricated butt strap and sealant. Fitting shall be insulated and weatherproofed using similar materials.
- F. Where indicated, all piping shall be covered with UV resistant Owens Corning PVC jacketing. Installation shall be in accordance with the manufacturer's limitation with regard to surface temperature and thermal expansion. Fittings shall be insulation as prescribed above, jacketed with pre-formed fittings covers matching the outer jacketing.

## 2.7. INSULATION SCHEDULE:

- A. Refer to insulation schedule on drawings.

## PART 3 - EXECUTION

### 3.1. EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
  - 1. Verify that systems to be insulated have been tested and are free of defects.
  - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2. PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

### 3.3. GENERAL

- A. All insulation shall be installed by skilled workmen regularly engaged in this type of work.
- B. Insulation shall be continuous at all hangers, sleeves and openings. Vapor seals shall be provided for all cold surfaces and shall be continuous.
- C. Arrange to permit expansion and contraction without causing damage to insulation or surface.
- D. Actual insulation thickness must be at least equal to the minimum specified in the schedule. Where the manufacturer's rated or nominal thickness is less than the minimum specified, a thicker material or more layers will be requested so that the stated minimum thickness will be attained or exceeded.
- E. Install insulation materials in a first class manner with smooth and even surfaces. Scrap pieces of insulation shall not be used where a full length section will fit.
- F. Unless otherwise specified herein, the application of all insulation materials, accessories and finishes shall be in accordance with the manufacturer's published recommendations.
- G. Insulation materials shall not be applied until all surfaces to be covered are clean and dry; all foreign material, such as rust, scale, dirt, etc., has been removed; and, where specified, surfaces have been painted. Insulation shall be clean and dry when installed and during the application of any finish. The insulation on pipe fittings, valves and pipe joints shall not be installed before the piping is tested and approved.
- H. Omit insulation on the following unless directed otherwise:
  - 1. Brass or copper pipe specified to be chrome plated.
  - 2. Traps and pressure reducing valves, relief piping from safety valves, and unions.
- I. Replace and repair insulation disturbed by testing and balancing procedures.

### 3.4. PIPE INSULATION

- A. High density pipe saddles shall be provided at all points of support as hereinbefore specified in Section 22 00 10.



- B. Insulate all valves and strainers. Use pre-molded covers and factory precut insulation where applicable. Unions and flanges shall not be insulated except on cold service.
- C. Insulate valves up to and including bonnets, except for cold water valves which shall be insulated over packing nuts in a manner to permit removal for adjustment and repacking.
- D. Insulate strainers in a manner to permit removal of the basket without disturbing the insulation of the strainer. Obtain Engineer's approval of installation method.
- E. Application - Types I Insulation
  1. Insulate all pipes in a neat and workmanlike manner. Seal all longitudinal laps of jackets and staple every six inches (6"). Where the piping operates below ambient temperature, the staples shall be coated with vapor barrier adhesive. All butt joints shall be wrapped with a three inch (3") minimum wide strip of jacketing material securely sealed in place.
  2. Insulate valves and fittings with pre-cut blanket type fiberglass insulation and PVC covers as specified. Insulation shall be of the same thickness as that on adjoining pipe. The ends of the insulation shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe covering tufted and tucked in, fully insulating the pipe fitting. The one (1) piece PVC fitting cover shall then be secured by stapling, tack fastening, banding or taping the ends to the adjacent pipe covering. Cold-water systems piping shall be insulated as above and have all seam edges of the cover sealed with ZESTON vapor barrier adhesive mastic. The circumferential edges of cover shall be color matching tape. The tape shall extend over the adjacent pipe insulation and overlap itself at least two inches (2") on the downward side.
  3. Where fittings are operating above ambient they may, in lieu of the preceding paragraph, be covered with a three hour (3 hr.), hydraulic setting, combination insulating and finishing cement having k factor not greater than 0.87 at a mean temperature of two hundred degrees Fahrenheit (200° F). The thickness of this cement shall be such that the surface is substantially flush with the pipe covering. Where the insulation terminates at a fitting that is not covered, the end of the insulation shall be beveled off with this same cement. All fittings insulated in this manner shall be covered by a fabric jacket as specified, which shall be cemented down with lagging adhesive.
  4. Where expansion joints are required to be insulated, they shall be covered with readily removable sections of insulation of same composition and thickness as provided for adjacent piping.
- F. Application - Type II Insulation
  1. The material shall be slit lengthwise to permit installation or slipped over pipe before connections are made.
  2. All joints and seams must be thoroughly bonded, both mechanically and hermetically, by the adhesive recommended by the insulation manufacturer. Also, the manufacturer's recommendations shall be followed as to the adhesive to use where the insulation needs bonding to metal or other material used for any surface treatment where a finish coat of paint is required.
  3. All penetrations of the insulation must be thoroughly sealed so that the insulation itself will form a complete vapor barrier. Wherever the insulation terminates, the edges shall be sealed to the metal.

G. Application - Type X Insulation

1. The material shall be applied lengthwise by placing the slit tubing over pipe. Longitudinal joint is made by peeling release paper from adhesive surface and applying pressure along longitudinal joint. Butt ends shall be secured with Armstrong 520 adhesive.
2. All joints and seams must be thoroughly bonded, both mechanically and hermetically, by the adhesive recommended by the insulation manufacturer. Also, the manufacturer's recommendations shall be followed as to use where bonding to other materials or metal is required.
3. All penetrations of the insulation must be thoroughly sealed so that the insulation itself will form a complete vapor barrier. Wherever the insulation terminates, the edges shall be sealed to the metal.

3.5. EQUIPMENT INSULATION

- A. Cut or score insulation to fit shape and contour of equipment. Stagger all joints.
- B. Provide permanently fastened angles or plates, where required to support insulation.
- C. Do not cover nameplates. Cut back the insulation and line edges with 26-gauge galvanized steel.
- D. Application - Type VI & IX Insulation
  1. Insulation shall be applied with staggered joints firmly butted and joined. The insulation shall be held in place by steel bands. Bands shall be spaced on not over twelve-inch (12") centers. All joints and voids shall be filled with cement, well troweled into openings. Apply over the insulation surface one inch (1") galvanized wire netting laced together at all edges and wired to the steel bands with 16-gauge soft annealed wire. Over this shall be applied a one-half inch (1/2") thick layer of insulating cement applied in two (2) layers. Install metal corner beads at all corners and edges to provide a permanent installation.
- E. Application - Type VII Insulation
  1. Apply a brush coat of manufacturer's recommended adhesive to dry, clean metal surface covering an area equal to the size of one (1) sheet. Apply a brush coat of adhesive to the back of the sheet, except for a one-half (1/2") wide border around the edges. After adhesive on metal surface and sheet has dried to a non-tacky state, position sheet so that the edges overlap the previously installed sheets by one eighth inch (1/8"). Apply light pressure to adhere a spot in the center of the sheet only and compress butt edges into place. Spread joints and coat with adhesive.

3.6. FINISHES

- A. PVC jacket shall be provided on all interior exposed piping, equipment, and ductwork herein specified to be insulated. PVC jacket shall be provided on sanitary and storm piping exposed to freezing conditions.

- B. Where PVC jacket is to be installed on piping, installation materials and procedures shall be in accordance with the manufacturer's recommendations.
- C. All pipes exposed to the weather shall be covered with aluminum jacket minimum 0.016 inch thick kept in place with aluminum bands 12 inches on center. Longitudinal seams shall be on underside of pipe and horizontal joints shall be lapped 3 inches with aluminum bands at edge of overlap.

END OF SECTION 22 07 00

## SECTION 22 08 00 - COMMISSIONING OF PLUMBING SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to the work specified in this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. The contractor is responsible for commissioning the systems and components in this section.
- B. The commissioning process requirements are outlined in Section 01 91 13 General Commissioning Requirements. Contractor is responsible for complying with all requirements listed therein.

END OF SECTION 22 08 00

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## SECTION 22 11 00 - PUMPS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to the work specified in this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Elevator sump pumps.

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with section 22 00 50.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include plans, elevations, sections, and mounting or attachment details.
  - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams for power, signal, and control wiring.
  - 5. Operation and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 GENERAL

- A. Pump capacities shall be as scheduled on the drawings.
- B. Reference Motor Specification Section 22 00 10 for efficiency and construction compliance. The motors shall be TEFC design.

- C. Data submitted for approval shall include pump speed and characteristic curves for performance of the impeller selected. Curves shall indicate capacity vs. head, NPSHR, efficiency and brake horsepower for the full range, from shut-off head to free delivery. Manufacturers' pumps may be considered only if pump efficiencies are equal or greater than the basis of design.
- D. Vibration isolation shall be provided as specified in Section 22 00 50.
- E. Base ells or support shall be provided under piping risers from pump and risers shall further be supported by calibrated spring hangers. Where pump arrangement precludes the use of base elbows or comparable supports, piping shall be supported by means of spring-loaded hangers calibrated for the specific use. Pump isolation bases shall be sized to accommodate the support ells.
- F. Pumps shall be selected so that the operating point on the selected impeller curve will be at or to the left of, and not more than 5% below, the point of maximum efficiency. Impeller size for specified duty shall not exceed 90% of volute diameter.
- G. Pumps shall be provided with motors conforming to Section 22 00 10. Motors shall not exceed 1750 rpm unless noted on pump schedule. Pumps shall be non-overloading with respect to nameplate horsepower throughout the impeller performance curve, unless specifically noted on pump schedule.
- H. The flush line to the mechanical seal shall be equipped with a 50 micron cartridge filter or when the pump differential exceeds 30 PSIG, a cyclone separator can be utilized with a signal flow indicator. The mechanical contractor shall change the filters after the system has been flushed and on a regular basis until the pumps are turned over to the Owner. At final acceptance new filters shall be provided.

## 2.2 CLOSE-COUPLED INLINE (Type "B" Pump)

- A. Pump shall be close coupled vertical or horizontal in-line type, single stage design. The pumps shall be capable of being serviced without disturbing piping connections.
- B. All Bronze construction, suitable for 175 psig working pressure at 250 deg. F. The casing shall incorporate a seal vent line to facilitate air removal and promote continuous water flush across the seal faces. The casing shall have tapped and plugged holes for priming, draining, and gauges.
- C. The impeller shall be of the enclosed type, vacuum cast in one piece and constructed of bronze, ASTM B584. The impeller shall be finished, the exterior being turned and the interior being finished smooth and cleaned. The impeller shall be dynamically balanced. The impeller shall be keyed to the shaft, fastened with a washer, gasket and capscrew.
- D. Shaft sealing shall be accomplished by means of a John Crane Mechanical seal suitable for 225°F operation. The seal shall have a ceramic seat, carbon washer, Buna-N elastomers, and stainless steel metal parts.
- E. The pump shaft shall be ground and polished stainless-steel shaft with stainless steel sleeve.

F. Pumps shall be manufactured by one of the following:

1. Armstrong Pumps, Inc.
2. Taco Pumps
3. Bell & Gossett Pumps
4. Grundfos

## 2.3 ELEVATOR PIT SUMP PUMP (Type "E" Pump)

- A. Contractor shall furnish and install a Stancor Oil-Minder System Pump or approved equal and control to allow water to be automatically pumped from a sump basin without danger of ejecting potentially harmful oily substances into sewers or drainage system. The system consists of:
  - B. Stancor Submersible Sump Pump rated as indicated on drawings with Double Mechanical Seal, Cast Iron Impeller and 3600 rpm. A Stainless Steel Oil Sensor Probe shall be mounted on the Pump. Pump shall be UL Approved and with Thermal and Overload Protection.
  - C. Junction Box shall be provided with NEMA 4X Enclosure, Factory Pre-Wired to the pump, oil probe and float switches via cables and with a Multipin Connector Cable to Remote Control Panel.
  - D. Provide Control Panel in a UL, NEMA 4X Enclosure with Visual & Audible Alarms and Auxiliary Contact.
  - E. Mechanical Float Switches, one for Normal On-Off operation and one for High Water Alarm, with cables.
  - F. The Pump, Control Panel, Float and Sensor Probe shall be ENTELA tested & certified and Approved by the local governing jurisdiction.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

### 3.2 PUMP INSTALLATION

- A. Install horizontally mounted, in-line, close-coupled centrifugal pumps with shaft(s) horizontal.
- B. Install all floor mounted pumps and pump packages on concrete housekeeping pads.
  1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.



2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    3. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - C. For inline pumps, install continuous-thread hanger rods and spring hangers of size required to support pump weight.
    1. Comply with requirements for vibration isolation devices specified in Section 22 00 50. Fabricate brackets or supports as required.
    2. Comply with requirements for hangers and supports specified in Section 22 00 50.
  - D. Install thermostats in hot-water return piping.
  - E. Install time-delay relays in piping between water heaters and hot-water storage tanks.
  - F. Install piping adjacent to pumps to allow service and maintenance.
  - G. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
    1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
      - a. Horizontally mounted, in-line, close-coupled centrifugal pumps.
      - b. Comply with requirements for flexible connectors specified in Section 22 00 50.
  - H. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping.
    1. Install pressure gage and snubber at suction of each pump and pressure gage and snubber at discharge of each pump. Install at integral pressure-gage tapings where provided or install pressure-gage connectors in suction and discharge piping around pumps.
  - I. Connect pressure switches, thermostats, time-delay relays, and timers to pumps that they control.
  - J. Interlock pump between water heater and hot-water storage tank with water heater burner and time-delay relay.
- 3.3 IDENTIFICATION
- A. Comply with requirements for identification specified in Section 22 00 10.

### 3.4 STARTUP SERVICE

- A. Provide start-up and adjustments for pumps in accordance with the manufacturer's recommendations using personnel who are factory trained and certified by the factory as factory authorized personnel.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Check piping connections for tightness.
  - 3. Clean strainers on suction piping.
  - 4. Set automatic starting and stopping operation of pumps.
  - 5. Perform the following startup checks for each pump before starting:
    - a. Verify bearing lubrication.
    - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    - c. Verify that pump is rotating in the correct direction.
  - 6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
  - 7. Start motor.
  - 8. Open discharge valve slowly.
  - 9. Adjust temperature settings on thermostats.
  - 10. Adjust timer settings.

### 3.5 ADJUSTING

- A. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust initial temperature set points.
- C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 22 11 00

## SECTION 22 13 00 - PLUMBING SPECIALTIES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 019113 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Cleanouts
  - 2. Drains
  - 3. Plumbing specialties
  - 4. Trap priming systems

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with section 22 00 50.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include plans, elevations, sections, and mounting or attachment details.
  - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams for power, signal, and control wiring.
  - 5. Operation and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 CLEANOUTS

- A. Cleanouts shall be placed in piping throughout the building, where noted and where required by code. Cleanouts on piping below floors, at ends of runs and changes of direction of piping shall consist of Y branches, the full size of pipes to which they are connected with cleanout

plugs and covers as listed below or as detailed. Extend cleanouts on concealed piping to finished walls, floors and grade. Cleanouts shall be Josam, Jay R. Smith, Watts, or Zurn equal to Josam numbers indicated below.

1. In concrete floor on grade (generally) - Series 58460A-AE-2 cleanout with scoriated round satin bronze top, bronze cleanout plug with lead seal, and adjustable housing. In carpeted areas, Josam Series 58460A-AE-2-14.
2. At base of vertical piping and in walls - Series 58910 cleanout tee with countersunk bronze threaded plug. Where risers are concealed, provide Series 58600-COT cleanout tee with plug tapped for center screw and stainless steel wall access cover.
3. Cleanouts on exposed horizontal piping shall be Series 58900 with bronze threaded plug.
4. Cleanouts in waterproofed equipment rooms - Series 58460A-AE-2-20 with bronze plug.

## 2.2 DRAINS

- A. Provide traps for all drains. All sanitary traps shall be "deep seal" type.
- B. Provide drains where indicated. Drains shall be Josam, Jay R. Smith or Zurn equal to Josam equipment as follows:
  1. Floor Drains – General, with Primer Tap      Type "A" 30000-6A-VP-50 (Nikaloy Top)
  2. Floor Drains – General      Type "B" 30000-6A-VP (Nikaloy Top)
  3. Floor Drains – Equipment, with Funnel      Type "C" 30000-7E3-VP-50 (Nikaloy Top)  
And Primer Tap
  4. Floor Drains - Mechanical Room      Type "D" 32100-11-50 (Cast  
Super Flow Large Capacity Iron Top)
  5. Area Drains      Type "E" 32300-VP (Cast Iron Top)
  6. Roof Drains      Type "F" 21500-AE-3-4-22 (Cast Iron Dome)
  6. Roof Drain (Overflow)      Type "G" 21500-AE-3-4-16GLV-22 (Internal  
Waterguard)

## 2.3 DOMESTIC WATER PRESSURE REDUCING VALVES

- A. Provide for the domestic cold and hot water systems pressure reducing valves which shall reduce the hot system pressure to the value shown on the drawings. The cold system valve shall modulate to maintain the cold piping to within +/- 5 psig of the hot piping.
- B. The valve shall be provided in the cold water line and shall sense the pressures remote of that valve. A high pressure line from the control shall be connected downstream of the main valve and shall sense the cold water pressure, with a low pressure line to be connected to the hot water line. As the pressure in the cold water side increases, the differential between the cold and hot systems shall increase. The control shall begin to close and the main valve shall modulate closed to keep the cold pressure the same as the hot pressure.
- C. Provide valves with the following accessories:
  1. Self-cleaning strainer provided in the main valve inlet body to protect pilot system from foreign particles.

2. Isolation valves to isolate pilot system from line pressure during servicing.
  3. Closing speed control to control closing speed of main valve.
  4. Opening speed control to control opening speed of main valve.
  5. Strainers in pilot lines.
- D. Valves shall be model 690G 01ABCSKc DB for piping 3" and larger and model CRD-L for piping 2-1/2" and smaller as manufactured by CLA VAL Company, or approved equal. Valves shall be ductile iron with epoxy coating, bronze trim and Buna N rubber. The pilot control shall be a bronze housing with stainless steel trim and Viton rubber, suitable for dead end domestic water service.

## 2.4 PIPE SPECIALTIES

- A. Manual Air Vents:
1. Manual air vents shall be key-operated type installed where indicated on the drawings or as required for proper venting of equipment. Vents at top of vent chambers shall be 1/4" brass cocks, Crane #2190 H or approved equal.
- B. Pressure Regulating Valves:
1. Pressure regulating valve shall be designed for 125 psig working pressure, set as required and shall be Watts Series LF25AUB-Z3. Relief valves shall be Watts Series 174A, ASME stamped or approved equal. Provide unions and pressure gauges upstream and downstream of pressure regulating valves.
- C. Backflow Preventers:
1. ASSE 1013 reduced pressure zone assemblies shall be Watts Series LF909 or approved equal, 3/4 inch size and larger, for piping systems. ASSE 1024 dual check valves shall be Watts LF7RU2-2. Elsewhere, vacuum breakers shall be Watts, or approved equal, Series 288A No. 9D for equipment and No. 8A for hose bibs.
- D. Strainers:
1. Strainers shall be Mueller Steam Specialty Company, Inc., or approved equal, No. 351 for 2" and smaller and No. 758 for 2-1/2" and larger. Screens shall be stainless steel with 1/32" perforations for water. Provide valved blowdown connections on each strainer consisting of a gate valve set between two short nipples. Bush strainer outlet as required for 3/4" maximum connection. Provide a fine mesh start-up screen to be removed after system cleaning.
- E. Pressure Gauges:
1. Gauges shall be Trerice, Ashcroft, Weiss, Winters, Crosby or Marsh equal to Trerice No. 450 series, liquid filled, 4-1/2" diameter case, bottom connected for easy reading. Dial shall have black letters on white background.
  2. Pressure gauges shall be suitable for field calibration.
  3. Each gauge shall be mounted within six feet of the floor on background or pipe mounted. Submit gauge locations and scale ranges for approval.
  4. Provide Apollo or approved equal 1/4" ball valve where "gauge cocks" are indicated or required.

5. Select gauge such that at normal service the gauge pointer is at the middle of the scale range.
- F. Thermometers:
1. Thermometers shall be Moeller, Terice, Weiss, Taylor, or approved equal. Thermometers shall be bi-metal type with adjustable angle, self-powered (no battery), 3/8" LCD digits display, Hi-impact ABS case, dual F&C switchable, temperature range - 40°F-300°F (-40°C-150°C), accuracy +/- 1% or 1°, whichever is greater. Unit shall be complete with brass socket with extension necks for insulated pipes.
  2. Thermometer (remote indicating type) shall be Weksler Series X, or approved equal, stainless steel casing, 4-1/2" dial, 0 degrees F to 120 degrees F reading, with Class 5A fully compensating capillary tubing (maximum length 25 feet), air temperature bulb and mounting bracket.

## 2.5 OTHER SPECIALTIES

- A. Hose connections inside of building shall be Chicago faucet #952 for 3/4" hose thread outlet lock shield cap and removable tee handle Chicago #293-6, polished chrome plated.
- B. Wall hydrants shall be Josam Series 71300-52 or approved equal, non-freeze with satin finish bronze face box and integral vacuum breaker.
- C. Provide Zurn or Josam shock absorbers equal to Josam Series No. 75000 where indicated, and sized in accordance with PDI Standard WH 201.
- D. Provide backwater valves in all floor drains connected to the storm water system, where required or indicated on the drawings. Backwater valves shall be Josam, J.R. Smith or Zurn equal to the Josam model listed below:
1. Floor Drains: Series "J" or Series 67100A
  2. Drain Lines: Series 67360 with extension to clean out cover.
- E. Trap Primer:
1. Provide flush valve primers where required and indicated on the drawings. Flush valve primer shall be Precision Plumbing Products Model FVP-1VB (with vacuum breaker) or equal by Sloan, Model F-72-A1. Provide 1/2" O.D. copper to floor drain connection.
  2. Provide automatic trap priming valve where required and indicated on the drawings. Automatic trap priming valve shall be Precision Plumbing Products PR-500, Prime-Rite or equal by MIFAB, Model MR-500. Provide trap primer distribution unit where required to serve more than one floor drain. Provide 1/2" O.D. copper to floor drain connection.
- F. Overflow roof drain downspout nozzle discharge shall be Josam Series 25010-Z-51-BS with satin finish bronze and stainless steel mesh screen.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install backwater valves in building drain piping. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
  - 1. Size same as drainage piping up to 4". Use 4" for larger drainage piping unless larger cleanout is indicated.
  - 2. Locate at each change in direction of piping greater than 45 degrees.
  - 3. Locate at minimum intervals of 50 feet for piping 4" and smaller and 100 feet for 5" and larger piping.
  - 4. Locate at base of each vertical soil and waste stack.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
  - 1. Position floor drains for easy access and maintenance.
  - 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
    - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
    - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
    - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
  - 3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
  - 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.
- G. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.
- H. Assemble open drain fittings and install with top of hub 2 inches above floor.
- I. Install deep-seal traps on floor drains and other waste outlets, if indicated.

- J. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
  - 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
  - 2. Size: Same as floor drain inlet.
- K. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- L. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- M. Install frost-proof vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- N. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- O. Install wood-blocking reinforcement for wall-mounting-type specialties.
- P. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- Q. Install piping adjacent to equipment to allow service and maintenance.

### 3.2 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
  - 1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
  - 2. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
  - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
  - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
  - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings.



- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

### 3.3 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
  - 1. Grease interceptors.

### 3.4 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 13 00

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## SECTION 223400 – DOMESTIC WATER HEATERS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Commercial, gas-fired, high-efficiency, domestic-water heaters.
  - 2. Domestic-water heater accessories.

#### 1.3 SUBMITTALS

- A. Submit Shop Drawings for all materials specified in this section in accordance with Section 220050.
  - 1. Include construction details, materials descriptions, dimensions of individual components and profiles, and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include plans, elevations, sections, and mounting or attachment details.
  - 3. Include details of equipment assemblies, indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams for power signal and control wiring.
  - 5. Operation and maintenance manuals.

#### 1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE/IESNA Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IESNA 90.1.
- C. ASME Compliance:
  - 1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

- D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."

## 1.5 WARRANTY

- A. Manufacturer will repair or replace any part of the equipment we manufacture that is found to be defective in workmanship or material within 18 months of shipment from the factory or 12 months from start-up (whichever comes first). Manufacturer should be notified in writing as soon as the defect becomes apparent.
- B. Each boiler shall be completely tested before leaving the manufacturing factory. This includes a hydrostatic pressure test prior to final assembly and factory test fired prior to shipment. Combustion must be set on all fuels and all firing rates. A factory test fire report and wiring diagram shall be provided with each boiler.
- C. The pressure vessel shall be guaranteed against thermal shock for 10 years (non-prorated) when utilized in a closed loop hydronic heating system with a maximum temperature differential rating of up to:
  - 1. Carbon Steel Units: 170 degrees Fahrenheit
  - 2. Duplex Alloy Steel Units: 100 degrees Fahrenheit.
- D. The boiler pressure vessel shall be guaranteed accordingly without a minimum return water temperature requirement. The boiler shall not require the use of flow switches or other devices to ensure a minimum flow through the boiler.
- E. The pressure vessel shall carry a 10-year warranty against material and workmanship defects. This warranty shall be non-prorated for the first 7 years and years 8-10 shall be pro-rated as per schedule posted on the current product warranty.
- F. The combustor and exhaust pipes (heat exchanger) shall be guaranteed against flue gas corrosion for a period of 10 years on carbon steel boilers or duplex alloy steel boilers. This warranty shall be non-prorated for the first 7 years and years 8-10 shall be pro-rated as per schedule posted on the current product warranty.
- G. All parts not covered by the above warranty shall carry a one-year warranty. This shall include all electrical and burner components.

## PART 2 - PRODUCTS

### 2.1 HOT WATER STORAGE TANKS: (LINED)

- A. Provide jacketed storage tank where indicated on the drawings, vertical or horizontal as configured on plans, as manufactured by Cemline Corporation, JST series, or approved equal. Storage tank shall be furnished as a complete factory jacketed and insulated pre packaged unit.

- B. Storage tank shall be steel constructed in accordance with Section IV of the ASME Code for 150 psig working pressure. The tank shall be registered with the National Board of Boiler and Pressure Vessel Inspectors. Furnish a signed copy of the Certificate of Shop Inspection.
- C. The interior of the tank shall be factory lined. Tanks above 36 inches in diameter shall have wire mesh completely welded over the interior prior to application of lining.
- D. The tank exterior shall be factory-painted with a high-quality rustproof primer, and then factory-insulated with 3"-thick dense fiberglass, minimum 3 lb per cubic foot. Tank and insulation shall be wrapped with a minimum 20-gauge steel jacket and the exterior coated in a corrosion-resistant baked enamel finish of manufacturer's standard colors.
- E. Provide a manhole, minimum 12 inch by 16 inch, or minimum 18 inch diameter, as required by ASME Code. Manhole shall be constructed as an integral part of the storage tank. Installing Contractor shall align manhole for inspection and service as indicated on the drawings.
- F. Tank shall be mounted vertically on a concrete pad, or suspended horizontally from structure above, in a location as shown on the drawings. Leveling bolts and coupling for pipe legs shall be factory furnished.
- G. Factory-fabricated openings in unit shall include as a minimum: Manhole as hereinbefore specified, pressure relief fitting, (2) inlets, (2) outlets, drain, vent. Provide all openings of manufacturer's standard sizes, except that minimum inlet and outlet sizes shall be 2-inch. All connections shall be Type 304 stainless steel threaded openings, and shall be extended through the jacket with red brass nipples. Escutcheons shall be used at all jacket penetrations.

## 2.2 CONDENSING, LOW-VOLUME, GAS-FIRED DOMESTIC-WATER HEATER

- A. Refer to schedule.

## 2.3 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect assembled domestic-water heaters and storage tanks specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test commercial domestic-water heaters and storage tanks to minimum of one and one-half times pressure rating before shipment.

## PART 3 - EXECUTION

### 3.1 DOMESTIC-WATER HEATER INSTALLATION

- A. Install domestic-water heaters on concrete base.
  - 1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.

2. Maintain manufacturer's recommended clearances.
  3. Arrange units so controls and devices that require servicing are accessible.
  4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
  5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  7. Install anchor bolts to elevations required for proper attachment to supported equipment.
  8. Anchor domestic-water heaters to substrate.
- B. Install domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping.
- C. Install gas-fired, domestic-water heaters according to NFPA 54.
1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
  2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
  3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
  4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves.
- D. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- E. Install combination temperature-and-pressure relief valves in water piping for domestic-water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- F. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains.
- G. Install thermometer on outlet piping of domestic-water heaters.
- H. Assemble and install inlet and outlet piping manifold kits for multiple domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each domestic-water

heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each domestic-water heater outlet.

- I. Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without integral or fitting-type heat traps.
- J. Fill domestic-water heaters with water.
- K. Charge domestic-water compression tanks with air.
- L. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

### 3.2 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 22 34 00

## SECTION 22 61 00 – MEDICAL GAS EQUIPMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to the work specified in this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Dry claw vacuum pump units.
  - 2. Medical gas valves and boxes.
  - 3. Alarm panels.
  - 4. Medical gas manifolds.

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with section 22 00 50.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include plans, elevations, sections, and mounting or attachment details.
  - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams for power, signal, and control wiring.
  - 5. Operation and maintenance manuals.

#### 1.4 EQUIPMENT CONNECTION

- A. Provide all connections required by medical gas equipment and devices equipment which is provided on this project. Certain items of equipment shall be provided under this section and certain items may be furnished and set under other sections of the specifications. In all cases, make final connections in accordance with manufacturers recommendations after equipment is in place.



## PART 2 - PRODUCTS

### 2.1 PIPE, VALVES AND FITTINGS

- A. Provide materials as hereinbefore specified in Section 22 00 50.

### 2.2 VACUUM PUMP UNIT (DRY-CLAW TYPE)

- A. Provide Beacon Medaes duplex packaged central vacuum unit mounted on a common skid with automatic lead/lag electrical controls and a receiver.
- B. Components, factory assembled by the manufacturer and interconnected with piping and wiring to constitute a functional package, shall include:
  - 1. Two dry-claw type standard pumps. Each vacuum pump shall be direct-driven through a shaft coupling by a NEMA C-face, foot-mounted, TEFC electric motor. Belt drives shall not be permitted. Each pump shall be air-cooled and have absolutely no water requirements. Each pump shall have an end (ultimate) vacuum of 29.3" Hg (15 torr), based on a barometric pressure of 29.92" Hg. Lubrication shall not be required. Pumps shall be dry running with no sealing or lubricating oil needed. The pumps shall be skid mounted in a vertical arrangement. Pumps shall be connected to a common manifold and piped to ASME coded receiver with drain valve. Each vacuum pump shall be equipped with a check valve, a ball-type isolation valve, and a flex connector between the pump and manifold. The pumps shall be mounted on vibration isolators.
  - 2. The electrical controls shall be housed in a NEMA 12 enclosure. The entire assembly shall be UL labeled. Control panels shall be listed in accordance with UL Standard 508A, "Standard for Industrial Control Panels". The control center shall alternate pumps on a demand basis when the lead pump turns off and on a timed basis to ensure approximately equal run time for each pump. All pumps shall be set to come on in a lead/lag sequence.
  - 3. Short-Circuit Current Rating (SCCR) of panel assembly shall be 5000A RMS Symmetrical Amperes, as determined by UL 508A Supplement SB method or by testing methods approved and verified by the listing agency.
  - 4. Electrical controls shall be of the automatic lead/lag type and shall consist of the following:
    - a. Two (2) magnetic motor starters with overload protection and motor branch circuit disconnects
    - b. One (1) low voltage control transformer with primary and secondary fuses
    - c. Two (2) hour meters
    - d. Two (2) Manual-Off-Auto switches with pump run lights
    - e. Two (2) dual set-point vacuum switches with adjustable differential
    - f. One (1) programmable controller
- C. One (1) ASME galvanized vacuum control tank. The tank shall be fitted with a pressure gauge, safety valve, and gauge glass. The tank shall be piped per the manufacturer's instructions to provide continuous draining of liquid and debris. The vessel shall not be installed as a dirt trap.

Piping must allow vacuum pump operation simultaneously with full tank bypassing per NFPA 99C to allow venting and maintenance while pumps are under operation providing central vacuum.

- D. The entire system shall be factory assembled and tested to ensure that all specifications are met.

## 2.3 MEDICAL GAS SHUT-OFF VALVES AND BOXES

- A. Multiple Zone Valve Box Assembly shall be constructed of 18 gauge steel with anodized aluminum cover frame and cover window with pull ring. Anchor brackets shall be designed to permit any number of boxes to be ganged together in a vertical stack.
- B. Shut-off valves shall be full port, double seal, ball type with Buna-N seals and O-ring packaging, chrome plated brass ball and designed for working pressures up to 300 psig. Only one-quarter turn of the handle shall be required to operate the valve from "open" to "closed" position; the valve handle shall protrude from the box and prevent the door from closing when the valve is in the "closed" position. Valve shall be securely mounted to back of zone box and provided with type L copper tube extensions to permit brazing outside of the valve box. All valves shall be serviceable in the line and supplied clean and prepared for oxygen service with pipe ends capped.
- C. Zone valve box assembly shall include 1-1/2" pressure gauges reading 0-100 psig for oxygen and air and 0-30 Hg for surgical vacuum. Vacuum shall be read upstream of the valve, oxygen and air shall be read downstream. Valves shall be piped left to right. Gauges shall be selected to read midway on the scale for "normal" operations. Sensor port and installation kit shall be provided in zone valve box to allow connection to area alarm panel.
- D. The zone valve box assembly shall be supplied with color coded gas identification labels. The window shall conceal exposed piping and valves within the box and shall have a caution label.
- E. Multiple zone valve box assembly shall be manufactured by Beacon Medaes Model 4107219 with gauges (Model 4107655) and sensors (Model 4107401) inside zone valve box. Refer to floor plans and zone valve box details for valve arrangements and sizes.

## 2.4 AREA LINE PRESSURE ALARMS

- A. Area alarm panels shall be designed to meet the requirements of NFPA and CSA standards. Area alarms shall be U.L. listed as an assembly and shall include all necessary gauges, factory wiring, transformers and circuitry requiring only 115 or 230 volt primary power. Internal voltage shall be stepped down to 5 volt and 20-volt control circuit power.
- B. Area alarm panels shall be modular in design and have one LED to indicate each normal/abnormal condition. Each gas monitor shall have an LCD to continuously indicate actual conditions.

- C. The Control Module will have a test switch and an alarm silence switch. The test switch tests all modules one at a time. There will also be a LED on the Control Module to indicate status of the micro-controller (green is normal, red is for a malfunction).
- D. Each Line Pressure Module shall have a normal/abnormal LED, LCD window, and a window for the gas label.
- E. Provide remote gas specific transducers for connection to remote sensors, located at each zone valve box.
- F. The master circuit board shall have two circuit breakers on the secondary side of the circuitry. It shall also contain dual transformers and selector switch to field select either 230 or 115 AC volt primary service. A detachable fuse holder on the primary side shall be included to insure that power is disrupted when the transformer cover is removed.
- G. The alarm audio tone shall be continuous. The sound intensity shall be 90 dBA. The audio signal shall be canceled only by the "alarm silence" button or fault correction.
- H. The audio alarm condition shall reactivate every half hour until the fault has been corrected. Regardless of the audio alarm the LED shall indicate "abnormal" as long as a fault condition exists. The alarm shall automatically reset with the correction of the fault condition.
- I. The panel will be equipped with dry contacts for each pressure/vacuum module. This will enable the alarm to interface with another alarm or central computer system.
- J. Digital area alarm panels shall be Beacon Medaes Model TotalAlert Infinity T3-A10 as indicated on the plans.

## 2.5 MEDICAL GAS OXYGEN MANIFOLD

- A. Provide one medical gas manifold for each of the oxygen systems, as manufactured by Beacon Medaes.
- B. Medical gas manifold assembly shall be constructed and installed in accordance with NFPA 99, National Electric Code, CSA/CAN, ANSI B57.1 and shall be factory furnished and U.L. listed as a complete assembly.
- C. Manifold assembly shall be provided with the following features:
  - 1. Full duplex line pressure regulators in four valve configuration with intermediate pressure service bypass.
  - 2. Fully automatic changeover from primary to secondary supply, including the rotation of primary bank to ensure emptying of cylinders.
  - 3. Central control unit factory assembled and pre wired.
  - 4. Separate 120 volt to 24 volt stepdown transformer.
  - 5. Pre-piped relief valves for connection to vent line, and a union for connecting to facility main.
  - 6. External header and pigtail connections, keyed to CGA V 1 connection.

- D. Manifold shall be floor mounted as indicated on the drawings.

## 2.6 CYLINDER STORAGE RACKS

- A. Wall Storage Racks: Fabricate racks with chain restraints for upright cylinders as indicated or provide equivalent manufactured wall racks.
- B. Freestanding Storage Racks: Fabricate racks as indicated or provide equivalent manufactured storage racks.

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
  - 1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1.
  - 2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.
    - a. Scrub to ensure complete cleaning.
    - b. Rinse with clean, hot water to remove cleaning solution.

### 3.2 PIPING INSTALLATION

- A. Comply with NFPA 99 for installation of medical gas piping.
- B. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
- E. Install piping adjacent to equipment and specialties to allow service and maintenance.
- F. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications.

- G. Install piping to permit valve servicing.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and for branch connections.

### 3.3 VALVE INSTALLATION

- A. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.
- B. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

### 3.4 COMPONENT INSTALLATION

- A. Install manifolds anchored to substrate.
- B. Install cylinders and connect to manifold piping.
- C. Install cylinder wall storage racks attached to substrate.

END OF SECTION 22 61 00

## SECTION 23 00 10 - MECHANICAL GENERAL PROVISIONS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SCOPE

- A. This section describes the general provisions for the mechanical and electrical work included in Division 23. This section applies to all sections of Division 23.

#### 1.3 RESPONSIBILITY

- A. The General Contractor shall be responsible for all work included in the Mechanical Division and the delegation of work to Subcontractors shall not relieve him of this responsibility. Subcontractors who perform work under these Sections shall be responsible to the General Contractor. The term "Contractor" is used throughout this Division and shall mean the General Contractor, although the actual performance of the work may be by a Subcontractor.

#### 1.4 REFERENCE AND DEFINITIONS

- A. Following are definitions of terms and expressions used in the Mechanical Sections. In addition to those used in Division 01 Sections.
  - 1. Owner: Greater Baltimore Medical Center
  - 2. Architects: Hord Coplan Macht
  - 3. Engineers: Leach Wallace Associates, Inc., Member of WSP
  - 4. Directed - "directed by the Architect"
  - 5. Indicated - "indicated or in Contract Documents"
  - 6. Concealed - "hidden from normal sight"; includes items in shafts, pipe and duct spaces, and above ceilings.
  - 7. Exposed - "not concealed" - Work within Equipment Rooms and all visible (normal sight) work shall be considered exposed".
  - 8. Concealed - "hidden from normal sight"; includes items in shafts, pipe and duct spaces, and above ceilings.
  - 9. Exposed - "not concealed" - Work within Equipment Rooms and all visible (normal sight) work shall be considered exposed".
  - 10. Piping -includes pipes, fittings, valves, hangers and accessories comprising a system.

11. Ductwork- includes ducts, fittings, housings, plenums, dampers, hangers, and accessories comprising a system.

#### 1.5 STANDARD SPECIFICATION

- A. See General Requirements of the contract.
- B. References to catalogs, standards, codes, specifications, and regulations are the latest edition in effect at date of invitation to bid.

#### 1.6 CODES, REGULATIONS AND PERMITS

- A. Give all necessary notices and obtain all required permits. Pay all fees and other costs, including utility connections or extensions in connection with the work. File all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments having jurisdiction. Obtain all required certificates of inspection and deliver same to the Architect before request for acceptance and final payment for the work.
- B. All materials furnished and all work installed shall comply with the latest rules, regulations, and recommendations of the following bodies:
  - International Building Code (IBC)
  - International Mechanical Code (IMC)
  - International Energy Conservation Code (IECC)
  - National Fire Protection Association (NFPA)
  - National Electrical Code (NEC)
  - Fire Prevention Bureaus of Baltimore County and the State of Maryland
  - Baltimore Gas and Electric (BGE)

#### 1.7 MATERIAL LIST AND SHOP DRAWINGS

- A. See General Requirements.
- B. Within 15 working days after the award of the Contract, the Contractor shall submit to the Architect for approval a list submittal to be included in the submittal schedule in accordance with Section 01 33 00 Submittal Procedures. The list shall include the manufacturers of material and equipment he proposes to provide. In the event any items of material or equipment contained in the list fail to comply with the specification requirements, such items will be rejected. Substitutions requests shall be submitted in accordance with specified procedure.
- C. After receiving approval of equipment manufacturers and prior to delivery of any material to job site and sufficiently in advance of requirements to allow the Architect ample time for checking, submit for approval, dimensioned drawings or cuts showing construction size, arrangement, operating clearances, performance characteristics and capacity of materials and

equipment. Each item of equipment proposed shall be a standard catalog product of the approved manufacturer.

- D. Samples, drawings, specifications, catalogs, etc., submitted for approval shall be properly labeled indicating specific service for which material or equipment is to be used, section and article number of specifications governing, and Contractor's name, name of job, and date.
- E. Catalogs, pamphlets or other documents submitted to describe items on which approval is being required shall be specific and identification in catalog, pamphlet, etc., of the item submitted shall be clearly made in ink. Data of a general nature will not be accepted.
- F. Any deviations or exceptions taken in the specification by the Contractor shall be so noted.
- G. If material or equipment is installed prior to receipt by the Contractor of approved shop drawings marked "Approved", "No Exception Taken" or "Make Corrections Noted", the Contractor shall be liable for its removal and replacement at no extra charge to the Owner.
- H. The acceptance of shop drawings shall not relieve the Contractor from his responsibility to furnish material, equipment and systems and to perform work required by the contract documents. Neither the Owner nor the Architect will be responsible for errors or omissions on shop drawings furnished by the Contractor even though such shop drawings containing errors or omissions are inadvertently accepted.
- I. The Contractor is further advised that the Architect will not act as coordinator between suppliers and subcontractors. All required coordination shall be the responsibility of the Contractor.

#### 1.8 CONTRACTOR'S USE OF CAD/REVIT FILES

- A. At the Contractor's written request, copies of the Engineer's CAD / Revit files may be made available for Contractor use in connection with the project, subject to following conditions:
  - 1. Submit written request to the Architect Listing the specific drawings the Contractor intends to use. Provide a specific list of submittals that the files will be used in preparing, and the list of names of subcontractors or suppliers.
  - 2. The Contractor shall request in writing the electronic transfer agreement. Prior to transfer of files, the Contractor shall prepare a separate electronic transfer agreement for each subcontractor or supplier who will be using the electronic files.
  - 3. Data contained on the electronic files is part of Leach Wallace Associates (LWA) Member of WSP instruments of service and shall not be used for any purpose other than as a convenience in the preparation of shop drawings for the referenced project. Any other use or reuse will be at the Contractor's sole risk and without liability or legal exposure to LWA.
  - 4. The electronic files are not contract documents. Significant differences may exist between the electronic files and the corresponding hard copy contract documents. Because of the possibility the information and data delivered in machine readable form may be altered, whether inadvertently or otherwise, LWA reserves the right to retain hard copy originals of the electronic documentation delivered to the contractor, in



machine readable form, which the original shall be referred to and shall govern in the event of any inconsistency between the two.

5. The use of the electronic files, does not relieve the Contractor of their duty to fully comply with the contract documents, including and without limitation, the need to check confirm and coordinate all dimensions and details, take field measurements, verify field conditions and coordinate work with that of other Contractors for the project.
6. All "internal" calculations integral to / performed by the Revit model shall not be utilized for any purpose by the Contractor. This includes, but shall not be limited to, voltage drop calculations, duct static pressure calculations, air system airflow summary calculations, piping system pressure drop calculations, etc.
7. All Revit "families" are the property of LWA and shall not be re-used on any other project for any purpose by the Contractor.

#### 1.9 GUARANTEE

- A. The Contractor guarantees by his acceptance of the Contract that all work provided shall be free from defects in workmanship and materials for a period of one year after date of certification of completion and acceptance of work. Any defects in workmanship, materials or performance which appear within the guarantee period shall be corrected by the Contractor without cost to the Owner within a reasonable time to be specified in notice from the Architect. In default thereof, Owner may have such work done and charge the cost of same to the Contractor.
- B. During the guarantee period, the Contractor shall service all major equipment items provided under this contract, including air handling units, pumps, and heat exchangers, which require outside service agencies. Service shall not include filter replacement, lubrication of motors and bearings or continuation of water and special system chemical treatment after formal acceptance of the systems by the Architect. Prior to the start of guarantee period, the Contractor shall provide the Architect with a schedule of required maintenance operations for each item of equipment. Submit schedule to the Architect for approval. Thereafter, monthly reports shall be submitted to the Owner for describing actual service provided. Forty eight (48) hours advance notice shall be given to Owner prior to work required under this Section.

#### 1.10 SITE VISIT

- A. Prior to preparing the bid, the mechanical subcontractors shall visit the site and familiarize themselves with all existing conditions. Make all necessary investigations as to locations of existing equipment, ductwork, piping, utilities, etc., work to be removed, and all other matters which can affect the work under the Contract. No additional compensation will be made to the contractor as result of his failure to familiarize himself with the existing conditions under which the work must be performed.

#### 1.11 DRAWINGS

- A. The contract drawings are diagrammatic and indicate the general arrangements of systems and work included in the Contract. Do not scale the drawings. Consult the architectural and structural drawings and details for exact location of structure and equipment; where same are not definitely located, obtain this information from the Architect.

#### 1.12 RECORD DRAWINGS

- A. The Contractor shall keep accurate records of all deviations in work are actually installed from work indicated. One complete set of contract documents shall be available at the construction site for indicating said deviations.
- B. When work is complete, make one (1) complete "As-Built" set of PDF files, certifying the accuracy of each drawing by endorsement and signature thereon and deliver to the Architect who will, after approval, deliver the record drawings to the Owner.
- C. Refer to Section 01 78 39 Project Record Documents for Specific Requirements.

#### 1.13 OPERATION AND MAINTENANCE INSTRUCTIONS

- A. Refer to Division 01, Section 01 78 23 for Operation and Maintenance requirements.
- B. Refer to Division 01, Section 01 79 00 for Training requirements.

#### 1.14 ELECTRICAL WORK

- A. Under Division 23 MECHANICAL, provide the following items of electrical work which shall conform with the applicable requirements of the Electrical Division:
  - 1. Temperature control wiring.
  - 2. Interlock wiring for mechanical equipment.
- B. Under Division 26, 27, or 28, provide:
  - 1. Power wiring complete from source to motor or equipment junction box, including power wiring through motor starters.
  - 2. Motor control centers or motor starter panelboards.
  - 3. All miscellaneous individual motor starters, local wall mounted control devices, unless noted or specified otherwise.
  - 4. All fire alarm interface wiring including smoke detectors located in mechanical systems.

#### 1.15 EQUIPMENT STARTUP AND INITIAL OPERATION

- A. No equipment shall be operated for testing or trial use except after full compliance with the equipment manufacturers' specifications and instructions of the lubrication, alignment direction of rotation, balance, and other applicable considerations.

- B. Particular care shall be taken to see that all equipment is completely assembled and properly lubricated and all grease and oil cases and reservoirs have been filled to the correct level with the recommended lubricant.
- C. It is the Contractor's responsibility to place each item of equipment installed by him in operating condition, including all auxiliaries, piping, wiring, etc., and to start up each unit and check it for performance.

#### 1.16 FIRE PROTECTION

- A. As minimum, one five pound CO2 extinguisher shall be provided with each work crew at all times when working within the building.

#### 1.17 SCHEDULE OF WORK

- A. Refer to project schedule. Specific phasing requirements are to be incorporated into the project schedule; contractor shall coordinate all work included in this division.

#### 1.18 SERVICE AGENCIES

- A. All mechanical equipment suppliers shall have an established authorized service agency located within the Greater Baltimore Metropolitan area. Within 30 days after award of the Contract, the Contractor shall submit to the Architect for approval a list of manufacturers' material and equipment names, including their respective service agency, he proposes to use. In the event any service agency in the list fails to comply with the specification requirement, such service agency will be rejected.

#### 1.19 SINGULAR NUMBER

- A. Where any device or part of equipment is herein referred to in the singular number (such as "valve"), such reference applies to as many such devices as are required to complete the installation, shown, implied or otherwise, as indicated on the drawings.

### PART 2 - PRODUCTS

#### 2.1 MATERIALS

- A. All materials shall be new, the best of their respective kinds, suitable for the conditions and duties imposed on them at the building and shall be of reputable manufacturers. The description, characteristics, and requirements of materials to be used shall be in accordance with qualifying conditions established in the sections following.
- B. See Division 01 for General Requirements.

- C. All component parts of each item of equipment or device shall bear the manufacturers' name plate, giving name of manufacturer, description, size, type, serial or model number, electrical characteristics, etc., in order to facilitate the maintenance or replacement. The name plate of a subcontractor or distributor will not be acceptable. All equipment requiring electrical service shall be U.L. labeled, or if a U.L. label is not available from the manufacturer, the equipment shall be tested by an approved electrical testing company in accordance with NEC, and at no additional cost to the Owner. Submit data indicating compliance with standards prior to installation.
- D. In specifying materials, four general procedures are used. The four classifications are as follows:
  - 1. GROUP 1: When the material or equipment is specified by name of other identifying information and one name brand only is used, it is considered that the use of that particular item is essential to the project, and the Contractor shall base his proposal on the uses of that item.
  - 2. GROUP 2: When a material or equipment is specified by brand name and other identifying information and two or more brand names are named, it is considered that any one of the brands so named will be performed as desired, and the Contractor shall base his proposal on one of the named brands.
  - 3. GROUP 3: When the material or equipment is specified with the phrase "... or equal..." after a brand name and other identifying information, it is intended that the brand name is used for the purpose of establishing a minimum acceptable standard of quality and performance and Contractor may base his bid proposal on any item which is in all respects equal to that specified and presents essentially the same appearance, size, operation and performance. The Contractor shall be responsible for coordination of the equal product.
  - 4. GROUP 4: When material is specified as complying with the requirements of published "Standard Specification" of trade associations, American Society for Testing and Material, government specifications, etc., the Contractor shall base his proposal on any item which can be shown to comply in all respects to the referred to "Standard Specification."
- E. All substitutions shall be submitted in accordance with Section 01 25 00 Substitution Procedures. It is distinctly understood: (1) that the Architect will use his own judgment in determining whether or not any materials, equipment or methods offered in substitution are equal to those specified and will fit within the space available; (2) that the decision of the Architect on all such questions of equality is final; and (3) that all substitutions will be made at no increases in cost to the Owner.
- F. Upon receipt of written approval from Architect, Contractor may proceed with substitution providing the Contractor assumes full responsibility for and makes, at his expense, any change or adjustment in construction or connection with any work that may be required by the substitution of such materials, equipment or methods. In the event of any adverse decisions by the Architect, no claim of any sort shall be made or allowed against the Owner.

## 2.2 PIPING SUPPORTS, GENERALLY

- A. Piping shall be run parallel with the lines of the building unless otherwise shown or noted on drawings. The different service pipes, valves, and fittings shall be so installed that after the covering is applied there will not be less than 1/2 inch clear space between the finished covering of parallel adjacent pipes. Hangers on different service lines running parallel with each other and nearly together shall be in line with each other and parallel to the lines of the building. Exact location of electric outlets, piping, ducts, and conduits shall be coordinated among the trades so that there will be no interference between lighting fixtures, piping, ducts, and conduits. Where conflicts between the trades result, they shall be resolved by the Contractor to the Architect's satisfaction and at no expense to the Owner.
- B. In general, hangers shall be spaced so as to prevent sag and permit proper drainage and shall not be spaced more than 10 feet apart unless otherwise indicated herein, Section 23 00 50 or on the drawings. Hangers shall be placed within one foot of each horizontal elbow.
- C. Vertical runs of pipe and conduit not over 15 feet long shall be supported by hangers placed not over one foot from the elbows on the connecting horizontal runs. Vertical runs of pipe and conduit over 15 feet long but not over 60 feet long and not over 6 inches in size shall be supported on heavy steel clamps. Clamps shall be bolted tightly around the pipes and conduits and shall rest securely on the building structure without blocking.
- D. Hangers shall be of manufacturers hereinafter specified in Section 23 00 50. Unless otherwise specified, pipe and conduit hangers and hanger supports shall conform with the following Anvil International figures:
  - 1. Hangers generally shall be Fig. 69, 104, 212, 260 and 300.
  - 2. Hangers Figs. 295 and 212 shall be provided with turnbuckles and eye rods or rods with eye nuts.
  - 3. Turnbuckles shall be Fig. 230 and 114, shall have not less than 1-1/2 inch adjustment, and shall be provided with lockouts.
  - 4. Clamps shall be Fig. 261 or CT-121.
  - 5. Wherever the movement of pipe due to expansion exceeds 3/4 inch per foot of hanger rod length, hangers shall be Figs. 171, 174 and 181.
  - 6. Roller supports shall be adjustable.
  - 7. Concrete inserts shall be Fig. 282 or 281.
- E. On copper pipes, hangers in contact with pipe shall be copper plated.
- F. In lieu of individual hangers, multiple (trapeze) hangers may be used for water pipes having same elevation and slope and for electrical conduits as specified hereinafter:
  - 1. Horizontal members shall consist of 1-1/2 inch by 1-1/2 inch No. 12 gauge, cold formed electro-galvanized dipped channels designed to accept special springheld hardened steel nuts for securing hanger rods and other attachments. Provide metal framing system with applicable fasteners, brackets, fittings, clamps, etc. Two or more such channels may be welded together forming horizontal members of greater strength than single channels. Members shall be Kindorf Series B-995, Unistrut, or approved equal.
  - 2. Each multiple hanger shall be designed to support a load equal to the sum of the weights of the pipes and liquid, the weight of the hanger rods shall be such that the stress at the root of the thread will not be over 10,000 psi at design load, except that no

- rod shall be smaller than 3/8 inch. The size of the horizontal members shall be such that the maximum stress will not be over 15,000 psi at design load.
3. Horizontal runs of piping along walls, 4 inch and smaller, exposed or concealed, shall be secured to metal framing system as specified herein. Provide appropriate clamps, brackets and similar attachments to secure piping to vertical members in accordance with applicable sections of the specification.
  4. On copper pipes in contact with horizontal member, provide rubber strip (Vibra Strip or equal) between hanger attachment and copper pipe.
- G. Hanger attachments shall be suitable for each type of hanger and shall be compatible with the building material to which it is secured. Under no circumstances shall pipe support be secured to any other mechanical, electrical or fire protection equipment. Support shall be suspended from building structure only. The type of attachments which shall be used for the various types of building construction encountered are as follows:
1. Steel beams - Fig. 226, or 66 attachments.
  2. Bar joists - Fig. 225, or 60.
  3. Brick or block walls - Fig. 194, 195, 199 or 202 fastened as follows: For light duty, self-drilling anchors in brick and toggle bolts in block; for heavy duty, through bolts with backing plates.
  4. Concrete (Existing) - Phillips "Redhead" or Rawl self-drilling anchors or expansion bolts.
  5. Concrete (New) - Inserts, Fig. 281 or 282. Power driver fasteners may be used for light loading as hereinafter specified.
- H. Welded attachments for securing hangers to piping or to structural steel may be provided in lieu of other attachments specified if prior approval is obtained in the field from the Architect. Welded attachments shall be designed so that the fiber stress at any point in the weld or attachment will not exceed the fiber stress in the hanger rod. Generally, welding shall not be permitted in finished spaces.
- I. On insulated piping at hangers, provide calcium silicate inserts and shields at each point of support, see Section 23 00 50 and Section 23 07 00.
- J. In no case shall wire or perforated strap be used for pipe or conduit support.
- K. Secure all hangers for piping and ductwork to joist and beams. In no case shall supports be secured to underside of metal or wood deck unless otherwise directed in the field by the Architect. Contractor shall submit details of method of attachments for approval to the Architect.
- L. Refer to Section 23 00 50 for vibration hanger requirements.
- M. Rooftop supports for mechanical piping, ductwork and equipment shall be constructed of heavy gauge galvanized steel with counter flashing, mitered and welded corner seams, integral base plate and 2x4 pressure treated wood nailer. Supports shall be model es-1, es-2, or es-5, and pipe roller supports shall be model prs-1 as manufactured by the PATE Company or approved equal.

- N. Pipe curb assemblies shall have heavy gauge galvanized steel curb, cap of acrylic clad abs thermoplastic graduated step PVC boots, adjustable stainless-steel clamps and cap fastening screws. Pipe curb shall be model PCA 1, 2, or 5 as manufactured by the Pate Company or approved equal. Contactor shall coordinate exact number and size of openings for piping and conduit penetrations of cap.
- O. Roof curbs shall be box section design heavy gauge galvanized steel, mitered and welded corner seams, integral base plate, pressure treated wood nailer, insulated with 1 ½" thick rigid fiberglass board insulation. Curbs shall be model pc-1, pc-2, or pc-5 as manufactured by the Pate Company or approved equal.

## 2.3 SLEEVES AND PLATES

- A. Pipe sleeves through concrete and masonry construction shall be Schedule 40 galvanized steel pipes unless otherwise indicated on the drawings. Openings that cannot be sleeved before slab or wall is poured shall be core drilled. Pipe sleeves through drywall and similar construction shall be sized to pass both pipe and insulation.
- B. Sleeves in existing concrete or masonry walls shall be set and secured with mortar grout and fast drying bitumastic sealant. Caulk the annular space of pipe sleeves with an elastic caulk compound to make installation air and watertight.
- C. Escutcheon plates shall be provided for all exposed pipes and conduits passing through walls, floors, and ceilings in finished areas. Plates shall be chrome plated brass of the split ring type, of size to match the pipe or insulation where installed. Where plates are provided for pipes passing through sleeves which extend above the floor surface, provide deep recessed plates to conceal the pipe sleeves.
- D. Except above suspended acoustical tile ceilings, provide 24 gauge galvanized sheet metal sleeves for all ductwork passing through floor, ceiling or wall construction. Duct sleeves shall be large enough to pass duct with insulation and shall have 1/2 inch flanges returned against the construction material.
- E. Where fire dampers are required, provide sleeves in compliance with code requirements, minimum 18 gauge galvanized sheet metal.
- F. Where watertight sleeves are indicated or required to suit the installation, provide Link Seal rubber seals, as manufactured by Thunderline Corporation, between pipes and sleeves.

## 2.4 MOTORS

- A. Provide motors of a size adequate to drive the equipment but in no case less than the size shown or specified. If a motor larger than that specified is required, the Contractor shall bear the expense of changes in foundations, support, wire and conduit connections, circuit protective devices, variable frequency drives, or other affected elements of the system. Each motor shall have sufficient capacity to start and operate the machine it drives without

exceeding the motor nameplate rating at the speed specified or at the load which may be obtained by the drive actually provided. Motors shall be rated for continuous duty at 115 percent of rated capacity; base temperature rise on an ambient temperature of 40°C.

- B. Motors for use with variable frequency controllers shall be "Inverter Ready", suitable for variable speed / variable torque applications, designed to withstand a rise time of 0.10 microseconds and a peak voltage of 1600 per NEMA MG1 Section 31.40.4.2.
- C. Motors 1/2 hp and larger shall be 3 phase, Class B, general purpose, squirrel cage, open type, high efficiency, induction motors unless noted otherwise. The rated nominal full load efficiency shall be in accordance with the following schedule when tested in accordance with NEMA test standards when wound for 208 or 480 volts, 60 Hertz, alternating current. Motors smaller than 1/2 hp shall be single phase, open capacitor type in accordance with NEMA standards wound for 115 volts, 60 Hertz, alternating current. Motors 1/6 hp and under may be split phase type.
- D. Motor efficiencies shall comply with the United States Energy and Independence and Security Act (EISA) of 2007 and the latest revision of NEMA Standard MG1 Table 12-2.
- E. Unless otherwise indicated each motor (5 HP or larger) or motor driven equipment (5 HP or larger) shall have a composite power factor (PF) rating of a minimum of 90% when the motor is operating at the design duty defined on the drawings. Power factor correction devices shall be provided to meet the stated criteria.
- F. Devices (such as: capacitors) or equipment (such as: solid state power factor controllers) when required for power factor correction shall be provided with the motors or item or motor driven equipment. The device shall be mounted and wired to the motor by the project electrical contractor.
- G. For a motor or motor driven equipment requiring other than across-the-line starting PF correcting capacitors (or other equipment) shall be connected to motor terminals via a contactor (controller) with a 120 VAC coil. The 120 VAC coil shall be energized via an auxiliary contact on the contactor (controller) used to establish the "run" operating mode for the motor or motor driven equipment.
- H. All motors for use with variable frequency controllers shall include a maintenance free, circumferential, conductive micro fiber bearing protection ring to discharge shaft currents to ground. Bearing protection rings shall be Aegis, model SGR, or approved equal. Bearing protection shall be installed and tested in accordance with the manufacturer's recommendations.

## 2.5 DRIVES FOR MACHINERY

- A. Equip each motor driven machine with a V-belt drive except those which are directly connected. Where factory designed and assembled belt drives which do not conform to the following are proposed to be furnished, such non-conformity must be noted on the submittals and such non-conformity may be cause for rejection of the item.



- B. Select each drive according to the rating and recommendation of the manufacturer for the service with which used, giving proper allowance for sheave diameter, center distance, and arc of contact less than 180 degrees. Size motors driving centrifugal fans so they have a nameplate rating of not less than 5 percent above the total of actual fan brake horsepower and drive loss at specified capacity if the wheel is of other than the forward curved blade type, and not less than 50 percent above the total of actual fan brake horsepower and drive loss at specified capacity if the wheel is of the forward curve blade type.
- C. Belts shall be constructed of endless reinforced cords of long staple Aramit, nylon, rayon, or other suitable textile fibers imbedded in rubber. Use belt with correct cross section to fit properly in the sheave grooves. Carefully match belts for each drive.
- D. Motor sheaves less than 20 HP shall be adjustable pitch type so selected that the required fan rotation speed will be obtained with the motor sheave set approximately in mid-position and have the specified pitch diameter in that position. Motors above 20 HP shall be provided with fixed sheaves to achieve the rated capacity of the fan. During the Commissioning Phase, if required to meet actual system requirements, a second set of sheaves and belts shall be provided and installed.
- E. Select the motor of a capacity needed to operate the equipment at the specified mid-position operating condition. Where non-overloading motors are specified, select the motor sheave. In no case shall motors be a smaller size than those shown.
- F. Do not select fan sheave smaller in diameter than 30 percent of the fan wheel diameter.
- G. Construct sheave of cast iron or steel, bored to fit properly on the shafts and secured with key ways (not set screws) or proper size, except key ways may be omitted for sheaves having 1/2-inch or smaller bores where set screws may be used.
- H. Provide OSHA approved guards for all belt drives, constructed in accordance with SMACNA standards. Submit shop drawings for approval.

## 2.6 DRIP PANS

- A. Where possible to run mechanical piping elsewhere, do not run mechanical piping directly above electrical (or electronic) work which is sensitive to moisture; otherwise provide drip pans under mechanical piping, sufficient to protect electrical work from leakage. Locate pan immediately below piping, and extend a minimum of 6" on each side of piping and lengthwise 12" beyond equipment protected. Fabricate pans 2" deep of reinforced metal with rolled edges and soldered or welded seams; 16 gauge steel with 2 oz. zinc finish hot dipped after fabrication. Provide 3/4" copper drainage piping, properly discharged, to nearest floor drain, service sink, or as directed in the field.

## PART 3 - EXECUTION

### 3.1 WORKMANSHIP

- A. Each subcontractor shall furnish the services of an experienced superintendent who shall be constantly in charge of the installation of the work.
- B. The quality of workmanship required for each trade in the execution of its work shall be the finest and highest obtainable in that trade working with the materials specified. Workmanship shall be satisfactory to the Architect and his decision as to acceptable quality if final.
- C. Contractor shall provide and execute a Quality Control Plan in accordance with Section 01 40 00 Quality Requirements.

### 3.2 EQUIPMENT CONNECTIONS

- A. All equipment shall be installed and connected in accordance with the best engineering practice and in accordance with manufacturer's instructions and recommendations. Auxiliary piping, valves, and electric connections recommended by the manufacturer or required for proper operation shall be provided.

### 3.3 COMMISSIONING RESPONSIBILITIES

- A. The mechanical contractor, and all the sub-contractors and suppliers within Division 23, shall cooperate with the commissioning agency (CA), and other commissioning team members, to facilitate the successful completion of the commissioning process.
- B. The contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decisions on behalf of the mechanical contractor as they relate to the organization and scheduling of HVAC commissioning. The representative shall ensure communications between Division 23 contractors and suppliers and all other commissioning team members, and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings, and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.
- C. The mechanical contractor, and all mechanical sub-contractors and suppliers, shall cooperate with the Commissioning Agency in carrying out the HVAC commissioning process. Refer to Division 01, Section 01 91 13 General Commissioning Requirements for additional information and requirements.

### 3.4 WATERPROOFING

- A. Under no circumstances shall waterproofing be damaged or penetrated. Should conditions arise which indicate such necessity, notify the Architect.

### 3.5 CUTTING AND PATCHING

- A. Cutting and patching associated with the work in the existing structure shall be performed in a neat and workmanlike manner. Existing surfaces which are damaged by the Contractor shall be repaired or provided with new materials and methods similar to existing adjacent work, subject to approval of the Architect. Structural members shall not be cut or penetrated unless otherwise indicated on the drawings. Verify in the field with the Architect. Holes cut through concrete and/or masonry to accommodate new work shall be cut by reciprocating or rotary non-percussive methods. Existing masonry block walls shall be patched with new masonry or gypsum board attached and sealed to both block faces.
- B. See General Conditions.

### 3.6 SURVEYS AND MEASUREMENTS

- A. Base all measurements (both horizontal and vertical) from established benchmarks. All work shall agree with these established lines and levels. Verify all measurements at site and check correctness of same as related to the work. Verify locations of existing utilities and inverts of same prior to the start of any systems shown connecting to utilities.
- B. Should the Contractor discover any discrepancy between actual measurements or conditions and those indicated which prevent following good practice or the intent of the drawings and specifications; he shall notify the Architect and shall not proceed with his work until he has received instruction from the Architect.

### 3.7 WELDING

- A. Welding shall conform to current standards and recommendations of the National Certified Pipe Welding Bureau, with all Maryland Occupational Safety and Health Acts, State, County and City Fire Prevention Code Requirements, Fire and Safety Regulations, and NFPA Standard 241 including provision of appropriate portable fire extinguisher.
- B. Before assigning any welders to work covered by this specification, the Contractor shall provide the Architect with the names of pipe welders to be employed for the work, together with each welder's assigned number, letter, or symbol which shall be used to identify the work of that welder and which shall be affixed immediately upon completion of the work, copies of each welder's certified qualification tests prescribed by the National Certified Welding Bureau or by other reputable testing laboratory using procedures covered in the American Society of Mechanical Engineers Building Construction Code, Section IX, "Qualification Standard for Welding and Brazing Procedures Welders, Brazers and Welding and Brazing Operators." Welders must be certified for all positions.
- C. If requested by the Architect, the Contractor shall submit identifying stenciled test coupons made by any operator in question. The Contractor shall require any welder to retake the tests when, in the opinion of the Architect, the work of the welder creates a reasonable doubt as to his proficiency. Tests, when required, shall be conducted at no additional expense to the

Owner; and the welder in question shall not be permitted to work as a welder on this project until he has been recertified. Recertification of the welder shall be made to the Architect only after the welder has taken and passed the required test; welder must pass the test without benefit or retests in order to resume work as a welder on the project.

- D. Welding for pressurization piping systems shall conform to American National Standards Institute (ANSI) American Society of Mechanical Engineers (ASME) B31.9, "Code for Pressure Piping, Building Services Piping". The Contractor shall be responsible for the quality of welding and shall repair or replace any work not in accordance with these specifications. Contractor shall, without cost to the Owner, check welds by radiograph, ultrasonic testing, sectioning or a combination of these methods wherever there is a question raised by the Architect as to the quality of a weld; examination of the questionable weld shall be in addition to other system tests specified. Welds shall have penetration complete to the inside diameter of the pipe and the recommended spacing and bevels between ends of pipe prior to welding shall be used in all cases to assure full penetration.

### 3.8 HANDLING AND STORAGE OF MATERIALS

- A. Proper and suitable tools, equipment and appliances for the safe and convenient handling and placing of all materials and equipment shall be used. During loading, unloading, and placing, care shall be taken in handling the equipment and materials so that no equipment or materials, including Owner furnished, are damaged.
- B. All mechanical and/or electrical equipment delivered to the job site shall be stored under roof or other approved covering, on pedestals above the ground. All enclosures for equipment shall be weatherproof. Any motors which are not totally enclosed, that are involved in the work, shall be stored in a heated area with a minimum temperature of 50 degrees Fahrenheit. All valves shall be stored under roof on wood pedestals above ground. All insulation shall be stored under roof or in trailers, adequately protected from the weather. The Contractor shall follow all written instructions and recommendations of the manufacturer and all requirements of the Architect in oiling, protection and maintenance of equipment during storage. It shall be the Contractor's complete responsibility for the storage and care of the equipment and materials.
- C. If any materials and/or equipment are found to be in poor condition at the time of being installed, the Architect may, at his discretion, order the Contractor to furnish and install new equipment at no cost to the Owner.

### 3.9 COOPERATION WITH OTHER TRADES

- A. Exact location of air outlets, electric outlets, piping, ducts, and conduits shall be coordinated with all other trades so that there will be no interference between lighting fixtures, piping, ducts, and conduits. Where conflicts between the trades result, they shall be resolved by the Contractor to the Architect's satisfaction and at no expense to the Owner.

- B. Mechanical trades shall give full cooperation to other trades and shall furnish in writing, with copies to Architect all information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay. Exact location of all mechanical equipment in finished spaces shall be coordinated with shop drawings and with elevations indicated on the architectural drawings.

### 3.10 CLEANING AND PAINTING

- A. Thoroughly clean all exposed surfaces of equipment and material and leave in a neat, clean condition ready for painting. Restore and touch-up factory finishes which have been damaged during construction. Finished painting will be performed under another Division.
- B. Miscellaneous requirements include:
  - 1. Provide complete new finish if, in the opinion of the Architect, the factory finishes are severely damaged.
  - 2. Touch up threads of zinc coated screwed pipe with Rustoleum primer and one coat of enamel conforming to painting specification.
  - 3. Paint behind grilles and registers in finished areas with two coats of flat black paint following surface preparation of the zinc coated metal.
  - 4. All exposed hangers, steel supports and miscellaneous components, and cast iron pipe hangers shall be field painted with Rustoleum primer and one coat of enamel conforming to painting specification.
  - 5. All steel support and miscellaneous components shall be painted with Rustoleum primer and one coat of enamel conforming to the painting specification.

### 3.11 ACCESSIBILITY

- A. Locate all equipment which must be serviced, operated or maintained, in fully accessible positions. Equipment shall include, but not be limited to, air terminal units, coils, valves, motors, controllers, dampers, drain points, etc. Where required and where directed, provide 14 gauge steel access panels, Milcor or equal, to suit material in which installed. Doors installed in fire rated walls or shafts shall be labeled and shall match rating of the construction. Door shall be of sufficient size to allow access to all components, except minimum size shall be 24" x 24", unless otherwise noted.
- B. Equipment deemed inaccessible by the Architect shall be reworked by the Contractor at no expense to the Owner. All doors shall have cylinder locks operable from same key. Submit shop drawings for approval.

### 3.12 EQUIPMENT BASES AND SUPPORTS

- A. All concrete bases, curbs, and supports shall be furnished under the Structural Division unless otherwise indicated. Under this Division provide all other equipment supports required for the plumbing work.

- B. The Contractor shall furnish all required foundation sizes, bolts, washers, sleeves, plates and templates for equipment.
- C. The size of the foundation bolts shall be as recommended by the manufacturer.
- D. The type and size of the supporting channels and supplementary steel shall be determined by the Contractor and shall be of sufficient strength and size to allow only a minimum, deflection in conformance with manufacturer's requirements for loading. Contractor shall submit details for approval to the Architect.

### 3.13 EXCAVATION AND BACKFILL

- A. Excavation: Refer to Section 31 20 00 Earth Moving
  1. Trenches shall be excavated to the necessary width and depth as shown on the drawings. The trench subgrade shall be such as to allow the bedding of the utility with a uniform and continuous bearing on solid, undisturbed earth for the full length of each pipe, except for that portion at the bell ends. The subgrade shall be graded with sufficient accuracy to assure this minimum. The bottom portion of all trenches from the subgrade to a point two feet (2') above the crown or top of the utility shall be as nearly vertical as practicable and at the minimum width.
  2. Trenches in fill areas shall not be excavated until embankment construction has been completed to a point at least two feet (2') above the crown or top of the utility being placed.
  3. Any part of the bottom of the trench excavated below the specified subgrade shall be back filled, at the Contractor's expense, with bedding materials as hereinafter specified. Whenever wet, or otherwise unstable, subgrade is encountered below the elevation of the original ground surface which existed prior to the time of construction, such soil shall be removed to the depth and extent directed by the Architect and the trench backfilled to the proper grade with bedding material as hereinafter specified. Reimbursement for extra work performed by the Contractor shall be in accordance with General Conditions. Whenever the Architect requires the removal of wet or otherwise unstable subgrade from the fill material previously placed by the Contractor, the cost of all removal of unstable soil, together with backfilling of the trench as herein specified shall be borne by the Contractor.
  4. Excavation for manholes and similar structures shall be of sufficient size to leave a minimum of twelve inches (12") and a maximum of twenty four inches (24") clearance on all sides. Any over-depth excavation shall be filled with concrete as directed and at the expense of the Contractor.
  5. Provide shoring and sheet piling necessary for excavation and for the safety of personnel and property as directed. Unless otherwise directed, the sides of all excavations over four feet (4') deep must be braced. All shoring, bracing, sheet piling, etc., must be solidly installed heavy timber suitable for the purpose. No lumber shall be buried when excavations are backfilled, except by authority of the Architect.
- B. Backfill: Refer to Section 31 20 00 Earth Moving

1. No backfill and/or bedding and backfill shall be placed until the construction adjacent or the utility to be backfilled has been inspected, tested and approved. Notify the Architect when inspections are required.
2. Backfill material shall be earth materials only, free from perceptible amounts of wood, debris, or topsoil and shall not contain marble or other elements which tend to keep it in a plastic state. The material shall be free of frost at the time of placement. Backfill for plastic pipes shall be clean sand, free of foreign materials.
3. Bedding materials, for use where trench subgrade is excavated below specified depth or for use at Contractor's option, shall be crushed stone or gravel, meeting the requirements of a S.R.C. No. 6 aggregate or crusher run S.R.C. CR-6 and shall be free of frost at the time of placing.
4. Work broken or ruptured by improperly placed backfill shall be removed and replaced by the Contractor at no additional cost to the Owner.
5. Following inspection as specified above, approved backfill material shall be deposited in the trench with hand shovels, not by means of wheelbarrows, carts, trucks, bulldozers, or similar equipment, in four inch (4") layers and compacted by mechanical tampers until the pipe has a cover of not less than two feet (2'). The remainder of the backfill material shall then be deposited in the trench in eight inch (8") layers and compacted. Any trenches improperly backfilled shall be reopened, then refilled and compacted to the required grade and smoothed off. Backfill shall be placed and tamped to achieve ninety five percent (95%) (percent of dry weight) compaction.
6. Field density tests may be required by the Architect in areas where, in his opinion, a question exists with respect to compliance with compaction requirements. These tests will be paid for at standard rates by the Owner, where the test results indicate compliance with the compaction requirements, and by the Contractor where the test results indicate non-compliance with compaction requirements. Density tests shall be performed by the methods specified in A.A.S.H.O. Designation T-147, the Field Determination of Density of Soil-In-Place.

### 3.14 SLEEVES AND PLATES

- A. Sleeves shall be provided by the trade installing the pipe or duct. The sleeves shall be carefully located in advance of the construction of walls and floors where new construction is involved. Provide all cutting and patching necessary to set sleeves which are not placed prior to construction. All cutting and patching necessary to set sleeves which are not placed prior to construction shall be the responsibility of the trade providing the sleeves.
- B. Sleeves shall be provided for all piping and ductwork passing through concrete, masonry, plaster and gypsum wallboard construction. Caulk the annular space of pipe sleeves with an elastic caulking compound to make installation, air, and watertight.
- C. Fasten sleeves securely in the construction so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials being forced into space between pipe and sleeve during construction.

- D. Sleeves required in existing concrete or masonry walls shall be set and secured with mortar grout and fast drying bitumastic sealant.
- E. At all sleeves where objectionable noise can be transmitted, at smoke barriers, at walls above ceilings that extend to underside of the structure of floor above, or at fire rated separations, seal all openings between pipes and ducts and corresponding sleeves to prevent sound transmission and to maintain fire rating. Use U.L. approved resilient sealant for penetration seals. Submit method of sealing for approval.
- F. Where pipe motion due to expansion and contraction will occur, provide sleeves of sufficient diameter to permit free movement of pipe. Where sleeves pass insulated pipes and ducts, the sleeves shall be large enough to pass the pipe or duct and the insulation. Check construction to determine proper length for various locations; make actual lengths to suit the following:
  - 1. Terminate sleeves flush with walls, partitions and ceilings.
  - 2. Terminate sleeves 2 inches above finished floor in equipment rooms, kitchen and wet floor areas.
  - 3. In all other areas, terminate sleeves 1/2 inch above finished floor unless otherwise noted on the drawings or directed in the field.

### 3.15 ALTERATIONS AND DEMOLITION

- A. All existing piping, equipment, ductwork, and materials which are required to be removed shall be removed. All existing materials and equipment which are removed and are desired by the Owner, or are indicated to remain as the property of the Owner, shall be delivered to him on the premises by the Contractor where directed by the Architect. All other materials and equipment which are removed shall become the property of the Contractor and shall be promptly removed by him from the premises.
- B. Remove all indicated mechanical work by hand as far as possible. Power-driven equipment shall be used as a last resort and shall not be employed without consent of the Owner. Schedule all demolition work to the satisfaction of the Owner. The Contractor shall execute the removal work as quietly as practicable to avoid unnecessary disturbances to occupied areas.
- C. Existing conditions, i.e. ductwork, piping, equipment, etc, may be obtained from available record drawings and are not warranted to be complete or correct. Contractor shall verify exact location of all ductwork, piping, etc, in the field prior to starting any work.
- D. Existing duct and pipe sizes noted on the available record drawings are for the convenience of the Contractor only. Contractor shall verify sizes in the field.
- E. Existing piping and ducts no longer required to remain in service shall be disconnected and removed back to service mains and trunk ducts, including existing piping hangers, supports, and air devices. Existing pipe and ducts indicated or required to remain in service shall be capped.



- F. Existing piping that remains concealed, buried, or otherwise contained in or below the remaining slabs and walls shall be capped, plugged, or otherwise sealed. All pipes shall be cut so that their capped or plugged ends will be far enough behind finished surfaces to allow for the installation of the normal thickness of finished material.
- G. When existing mechanical work is removed, all related pipes, valves, ducts, and materials shall also be removed.
- H. When the work specified herein connects to existing piping, or ductwork, the Contractor shall perform all necessary alterations, cutting, or fitting of the existing work as may be necessary or required to make satisfactory connections between the new and existing work and to leave the completed work in a finished and workmanlike condition, to the entire satisfaction of the Architect.
- I. When the work specified herein or under other divisions of the contract necessitates relocation of existing mechanical equipment, piping or ductwork, the Contractor shall perform all work and make all necessary changes to existing work as may be required to leave the completed work in a finished and workmanlike condition, to the entire satisfaction of the Architect, and at no additional cost to the Owner.
- J. Existing mechanical equipment, piping and ductwork affected by removal or new work installation and required to remain in service shall be reinstalled or supported as required in accordance with new work specification. All work shall be completed to the Architect's satisfaction and at no additional cost to the Owner.
- K. Valve off or disconnect live services as required for removal work.
- L. Refer to drawings for additional requirements.

### 3.16 FLASHING

- A. Openings for pipes and ductwork through waterproofed floors and roof areas shall be flashed. Vent pipes shall be flashed with 4 lb. sheet lead 24 inches square. Flashing shall be extended up around vents, which shall terminate not less than 12 inches above roof, and shall be fastened under vent caps.
- B. Refer to Architectural drawings and specification for additional roof flashing requirements.

### 3.17 COORDINATED DRAWINGS

- A. Prior to installation of mechanical work in all areas of the building including exposed areas (spaces without ceilings), the Contractor shall prepare completely coordinated layout drawings indicating the coordinated work of all trades involved. The drawings shall be a sheet size similar to the contract drawings. All work shall be to scale minimum 1/4" = 1' - 0". The drawings shall include all work shown on the drawings, including equipment (air handling units, pumps, etc), variable frequency controllers, ATC control panels, terminal units,

ductwork, air devices, dampers, piping including sprinkler and plumbing, valves, light fixtures, electrical cable trays, raceways, and conduits 1" and larger.

- B. All trades shall be responsible for the preparation of the coordinated layout drawings. Each trade shall provide written certification that the coordinated drawings have accurately incorporated their work, and that all conflicts are resolved or a solution is proposed on the drawings. The Contractor shall schedule the trades accordingly and shall provide final certification that all coordination has been completed.
- C. No work shall be installed prior to the Architect's approval of the drawings. The Contractor shall submit for approval of the Architect within 15 days after the award of the contract a schedule of proposed building areas to be grouped for coordination. Upon approval of the schedule, work may commence in areas of the building upon approval of that area's coordinated drawings prior to approval of another area.

### 3.18 CLOSE OUT PROCEDURES

- A. Refer to Section 01 77 00 close out procedures for specific requirements.

END OF SECTION 23 00 10

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## SECTION 23 00 50 – HVAC BASIC MATERIALS AND METHODS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications apply to the work specified in this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. This section includes requirements for items of equipment, materials and procedures which are common to more than one section of Division 23 and which are general in nature and use. This section applies to all sections of Division 23.
- B. The requirements of Section 23 00 10 HVAC, Mechanical General Provisions, shall apply to all work specified under this section.

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all items of materials specified in this section in accordance with the Section 23 00 10 and Division 01 requirements.
- B. At a minimum, manufacturer's product data shall include specifications, installation instructions and general recommendations for each type of material required. Include data substantiating that proposed materials comply with specified requirements for each type.
- C. Before ordering any Tag and ID materials conduct a coordination meeting with facility O&M staff and CxA to coordinate with existing hospital nomenclature. Submit a proposed tagging method for each valve, device, fixture and equipment incorporating unique ID's and room numbers for approval.
- D. Grooved joint couplings and fittings shall be referred to on drawings and product submittals and be identified by the manufacturer's listed model or series designation.

#### 1.4 TESTS AND ADJUSTMENTS

- A. The Contractor shall furnish labor, instruments, equipment, and materials required to perform tests prescribed in the sections describing the various systems.
- B. Replace or repair defects found during inspection or test with new materials. Caulking of welded joints, screwed joints, cracks, or holes is not acceptable. Correct leaks in screwed fittings by remaking joints. In welded systems leaks in joints shall be cutout and rewelded. Repeat tests after defects have been eliminated.

- C. Where reasonable doubt exists as to a system's ability to comply with contract requirements, perform any reasonable test required by the Architect.
- D. Make static pressure tests and prove to the satisfaction of the Architect that the piping is tight before pipes are concealed or insulated. Tests shall be provided as hereinafter specified.
- E. Use test instruments for accuracy by an approved laboratory or by the instrument manufacturer and furnish certificates showing degree of accuracy to the Architect when requested. Make calibration histories for each instrument available for examination.
- F. Where gauges, thermometers and other instruments which are to be left permanently installed are used for tests, do not install until just prior to the tests to avoid possible changes in calibration.

## PART 2 - PRODUCTS

### 2.1 HANGERS

- A. Refer to Section 23 00 10.
- B. Hangers and accessories shall be Anvil International, Fee and Mason, Modern, National, or B-Line of the types specified in Section 23 00 10.
- C. It shall be the responsibility of the Contractor to provide an adequate pipe suspension system in accordance with recognized engineering practices, using standard, commercially accepted pipe hangers and suspension equipment.
- D. The design of all hangers and support shall be in accordance with the provision of the current issue of MSS-SP-58 document developed as a standard by the Manufacturers' Standardization Society.
- E. Hangers for steel pipe, except as noted otherwise shall be spaced at least every ten (10') feet. Hangers for cast iron pipe shall be provided at each joint. Hangers for copper pipe shall be placed at least every eight (8') feet, except pipes 1 1/4" inch and smaller shall have hangers at six (6') foot intervals. Polyvinyl chloride pipe (PVC) shall have hangers at four (4) foot intervals.
- F. Where concentrated loads of valves, fittings and similar items occur, or if recommended by the piping manufacturer, closer hanger spacing will be necessary.
- G. Generally, hangers shall be clevis type, standard weight.
- H. Vibration hangers shall be provided as specified.
- I. On insulated piping systems, provide Pipe Shields, Inc., Model CS-CW or approved equal hanger shields at each point of support. Diameter of hanger shield shall match thickness of the insulation. In lieu of, provide wood dowel insert and minimum twenty gauge protection shield at each point of support. Diameter of insert and shield shall match thickness of the insulation and encompass 50% of insulation surface. On cold systems seal insert vapor tight with appropriate coating.

- J. Hangers in direct contact with copper piping systems shall be copper plated.

## 2.2 IDENTIFICATION AND EQUIPMENT TAGS

- A. All control devices, i.e. panels, switches, starters, push button stations, temperature controls etc., shall be clearly identified as to their function and the equipment controlled.
- B. All mechanical equipment shall be marked to clearly identify said equipment and space or duty they serve. All air terminal units and their corresponding thermostats shall be marked with sequential numbers to identify each terminal unit with its respective control thermostat.
- C. Mechanical equipment herein specified shall be identified using engraved laminated black and white phenolic legend plates. Letters shall be minimum, 3/4" high white on surrounding black. Plates shall be mounted by means of sheet metal screws. Submit nameplate list to Architect for approval.
- D. Mechanical and electrical equipment, i.e., air terminal units, valves, etc., concealed above ceiling shall be identified as to location using clear plastic self-adhesive tape with black lettering, applied to ceiling tile "T" bars. Submit nameplate list to Architect for approval.
- E. Piping shall be identified with colored, pre-rolled, semirigid plastic labels as manufactured by Seton, Marking Services, Inc., or approved equal. For indoor installations, labels shall be Seton "Set Mark" system. For outdoor installations, labels shall be Seton "Ultra Mark" system. Labels shall be set around pipes with a field installed high strength cement around pipes with a field installed high strength cement compound applied along their longitudinal edge. Labels shall be placed around the piping or insulation every forty feet (40) and with one (1) label on each pipe in rooms smaller than fifteen feet (15). A label shall be placed at every major valve and at least six feet (6) from exit or entrance to an item of equipment. At Contractor's option, piping concealed above suspended ceilings only, may be identified by stenciling with black paint and taped color bands in accordance with the coding system herein specified.
1. Labels shall be provided in accordance with the following table with color coding and stencil designations as indicated:

### SIZE OF LETTERS

Outside Diameter of Pipe (Inches)	Length of Color Field (Inches)	Size of Letters (Inches)
3/4" to 1-1/4"	8"	1/2"
1-1/2" to 2"	8"	3/4"
2-1/2" to 6"	12"	1-1/4"
8" to 10"	24"	2-1/2"

Over 10"                      32"                      3-1/2"

2. Color coding and stencil designations shall be as follows:

<u>Service</u>	<u>Color</u>	<u>Stencil Designation</u>
Hot Water Heating Supply	Yellow	Hot Water Heating Supply
Hot Water Heating Return	Yellow	Hot Water Heating Return
Steam	Orange	Steam (Designate Pressure)
Steam Condensate	Orange	Steam Condensate

- F. In addition to labeling as specified hereinbefore, all piping exposed within the penthouses, exposed within mechanical and electrical equipment spaces, utility spaces, janitor's closets, and piping elsewhere "exposed" as defined in Section 23 00 10, shall have full color coding, painted in a color identifying system type. Paint colors shall conform to the following schedule:

Hot Water Heating	Yellow
Steam (all pressures)	Orange
Steam Condensate	Orange

- G. Ductwork shall be identified by stenciling. Stenciled lettering shall be minimum 3 inches high with adjacent direction of air flow arrows. Stenciled lettering shall be provided on all mains and principle duct branches. Mark each type of service every 30 feet with a marking of each shaft. Identify ductwork as follows:

Air Handling Units	AHU-
Return Systems	RF-
Exhaust Systems	EF-
Isolation Exhaust Systems	EF-ISO-

- H. All valves, except as specified below, shall be provided with colored plastic or brass valve tags with stamped-in numbers. Tags shall be secured to valve wheels with metal chain. Stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent, need not be so equipped. Care shall be exercised in selecting valve numbers to be prepared on tracing linen showing locations, details of arrangements, etc., of all service and control valves indicating identity and function. One black line print of each drawing shall be mounted under glass where directed. Valve tags shall be

Seton or approved equal minimum 1-1/2" round tags with white characters describing system and valve designation. Submit valve number list for approval.

- I. All ductwork and fan discharge locations where critical infectious exhaust is a concern shall be so labeled "Critical Infectious Exhaust".

## 2.3 PIPES, FITTINGS AND JOINTS

### A. General

1. Piping materials shall conform to state and local code requirements. Pressurized piping systems shall conform to American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME) B31.9, "Code for Pressure Piping, Building Services Piping". High-pressure piping shall conform to ANSI/ASME Section I, B31.1, "Code for Pressure Piping, Power Piping".
2. Quality and weight of materials shall comply with requirements of applicable American Society of Testing Materials (ASTM), ANSI, ASME, and Cast Iron Soil Pipe Institute (CISPI) standards. ASTM number and wall thickness shall be indicated on each pipe length.
3. Provide pipe and fittings for systems as hereinafter specified. All references to codes shall apply to the latest year. Grooved products may be as manufactured by Victaulic or Grinnell. All piping and fittings shall be made in America.

### B. Pipe materials

1. Hot Water Heating Supply and Return, 2-1/2" and larger
  - a. Black steel pipe
    - 1) ASTM A53B seamless ANSI Schedule 40 with steel butt-welded fittings ANSI B16.9 using long turn ells, ANSI B16.5 weld neck or slip-on flanges & Bonney Forge Weldolets and Thredolets. Joints shall be welded in accordance with the Engineering Standards of the Mechanical Contractors Association of America Inc., Part VII, Standard Procedure Specifications Nos. 1 and 2. Piping 12" and above shall be standard weight. Fittings shall be "Made in America."
2. Hot Water Heating Supply and Return, 2" and smaller (contractor shall provide one of the following)
  - a. Black steel pipe
    - 1) ASTM A53A ANSI Schedule 40 with black malleable iron 175 lbs, screwed fittings, ANSI B16.3, joints threaded in accordance with the American Standard for pipe threads, ANSI B2.1. Fittings shall be "Made in America."
  - b. Seamless copper water tube



- 1) ASTM B88, Type L, hard tempered with wrought copper solder joint fittings 150 lbs., ANSI B16.22. Joints soldered with ASTM B32 tin-antimony 95.5 or Taramet Sterling "lead free" solder or equivalent.
  - 2) Alternate fitting - Press Fitting: Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22 and performance criteria of IAPMO PS 117. Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer. Press ends shall have SC (Smart Connect) feature design (leakage path).
3. Refrigerant Piping
  - a. Piping shall be seamless copper tubing, hard drawn type K or L, ASTM B88 with solder joint fittings, ASME/ANSI B16.22. Piping connections to equipment less than 1" in outside diameter may be soft annealed copper tubing ASTM B-180 with flared tube fittings, UL-109.
4. Steam Supply, Pressure Relief, and Vent Piping, 2-1/2" and larger
  - a. Black steel pipe
    - 1) ASTM A53A ANSI Schedule 40 with steel butt-welded fittings ANSI B16.9 using long-turn ells, ANSI B16.5 weld neck or slip-on flanges and Bonney Forge Weldolets and Thredolets. Joints shall be welded in accordance with the Engineering Standards of the Mechanical Contractors Association of America Inc., Part VII, Standard Procedure Specifications Nos. 1 and 2.
5. Steam Supply, Pressure Relief, and Vent Piping, 2" and smaller
  - a. Black steel pipe
    - 1) ASTM A53A ANSI Schedule 40 with cast iron 125 lbs., screwed fittings, ANSI B16.4, joints threaded in accordance with the American Standard for pipe threads, ANSI B2.1.
6. Steam Condensate Return Piping, 2" and smaller
  - a. Black steel pipe
    - 1) ASTM A53A ANSI Schedule 80 with wrought iron 250 lbs., screwed fittings, ANSI B16.4, joints threaded in accordance with the American Standard for pipe threads, ANSI B2.1.

## 2.4 VALVES

### A. General:

1. Valves shall be provided where indicated on drawings and as herein specified.
2. Valves shall be placed in such a manner as to be easily accessible for handwheel operation and stuffing maintenance.

3. Valves in piping where shown and where listed herein:
    - a. To balance flows in heating water piping.
    - b. To isolate all items of equipment.
    - c. To isolate motorized flow control valves.
    - d. To isolate branch lines and riser at mains.
  4. Valve pipe connections shall be screw, solder, welded, flanged or Victaulic as required to be consistent with other parts of the piping system.
  5. Where piping or equipment may subsequently need to be removed, provide valves with bodies having integral flanges or full lugs drilled and tapped to hold valve in place so that downstream piping or equipment can be disconnected and replaced with blank-off plate while valve is still in service.
  6. In mechanical rooms, valves over ten feet above standing level and above 4" in size shall have chain wheel with chain extending to within six feet of standing level. All wheel operated valves shall have an indicator to show the position of the disc or plug.
  7. Install valves in accessible locations and adjust for smooth and easy operation.
  8. Valves for equipment and controls shall be installed full size of pipe before reducing size to make connection.
  9. Where there is no interference, shut-off valves shall be installed with handwheel down on horizontal runs of pipe to prevent accumulation of foreign matter in packer between seats at closing end of wedge.
- B. Balancing Valves:
1. Provide balancing valves where indicated and required to balance water flow through the piping system. For pipe sizes 2 1/2" and larger provide separate balancing valve and flow meter fitting.
  2. Balancing valve for system piping shall be DeZurik, Homestead or approved equal eccentric plug valve as follows: flanged 2-1/2" and larger, with Fluorinated Hydrocarbon filler in a PTFE U-ring (packing) and CIIR or EPDM plugs and Chloro-Isobutene Isoprene plug facing suitable for -20 degrees F to 250 degrees F continuous operation. Valves shall have lever actuators with adjustable memory stop. For 2" and smaller, provide combination balancing and flow fitting with screwed ends as manufactured by Nexus, Tour & Anderson, or approved equal.
- C. Butterfly Valves - General HVAC Duty:
1. Butterfly valves shall be provided in hot water systems size 4" and larger.
  2. Butterfly valves shall be Crane/Centerline, Nibco, Bray or DeZurik equal to DeZurik Model BGS resilient seated butterfly valve installed with welding neck companion flanges.
  3. Butterfly valves shall be of the lug body style suitable for use with ANSI 125 or 150 pound flanges. Bodies shall be ductile iron or cast iron. Valves shall be manufactured in accordance with MSS-SP67 rated at least 200 psi non-shock cold water working pressure. Bodies of all flangeless wafer valves shall have 4 flange bolt guides to center the body in the pipeline. Body to have 2" extended neck for insulating.
  4. All valves shall have retained seat and shall provide bubble tight shutoff up to the full valve rating without the use of downstream flanges.
  5. All valves shall be furnished with bronze self-lubricated bearings. Shaft seals shall be provided to prevent leakage and to protect bearings from internal or external corrosion.

Bearings shall be provided at the operator connection and at points immediately outboard of the seat.

6. Seats shall be of the reinforced resilient type. Seats shall also act as a body liner to prevent flow from contacting the body casting. Seats shall have flange sealing to provide a positive seal without use of flange gaskets.
7. Shafts shall be one piece and shall be of Type 416 stainless steel and shall not have exposed stem-to-disc fasteners. Shaft diameter shall meet the 75B standard from AWWA specification C504-87 for butterfly valves. Shafts shall be finish ground to minimize bearing and shaft seal wear. Shafts of 12" and larger shall have non-adjustable thrust collar.
8. Discs shall be aluminum bronze, with EPDM rubber seat. The disc-to-shaft connections shall be Type 316 stainless steel. Pins, shaft and disc of all valves shall be individually machined and completely interchangeable.
9. Actuator for valves shall be lever type with locking trigger with notched quadrant. Sizes 8" and larger shall have weatherproof gear operators. All actuators shall have adjustable memory stops. All actuators manual or automatic shall be provided by the valve manufacturer.
10. Valves shall be lug-style and capable for use as isolation valves and recommended by the manufacturer for dead-end service at full pressure without the need for downstream flanges.
11. Each valve shall have a metal tag permanently affixed to the valve listing the following information:
  - a. Manufacturer.
  - b. Valve model/series designation.
  - c. Valve body material.
  - d. Disk material.
  - e. Seat material.
  - f. Certified pressure rating.

D. Ball Valves:

1. Ball valves shall be used in lieu of gate valves in all hot water heating piping systems size 3" and smaller for shut-off service. Ball valves shall be Apollo.
2. The body and bonnet shall be ASTM B283 brass. Ball shall be Type 316 stainless steel. Stem shall be stainless steel. Seats shall be RPTFE.
3. Stem shall be blowout proof and externally adjustable to compensate for wear. Valve shall be equipped with vinyl covered lever handle which shall indicate position of ball orifice and shall have stops for fully open and closed position. Construction shall be such that power actuator can be used. Ball opening shall be full pipe size.
4. Valve shall be suitable for flow in either direction and shall be rated 150 psig SWP and 600 psi CWP for sizes 1/4"-2" and 400 psi CWP for sizes 2-1/2"-4". Valve shall be capable of performing in systems with operating temperatures between 0°F and 400°F.
5. Valve shall be so constructed with three-piece cast brass bodies, full port design, with adjustable stem packing.
6. Ball valves used for balancing shall have adjustable memory stop. For use in insulated piping systems provide 2" extended handles of non-thermal conductive material.

E. Drain Valves:

1. Drain valves shall be ball valves with hose end connections and shall be provided at low points of all piping system and where indicated or required, 3/4" minimum. Provide Nibco Series 585-70-HC or approved equal. Valve shall be rated for 125 lbs.

F. Valve Schedule:

1. Unless otherwise specified, valves shall be Grinnell, Stockham, Crane, Jenkins, or Nibco equal to the Nibco figure numbers indicated herein:
2. Hot Water Heating:
  - a. Ball - 2" and smaller
  - b. Check - 2-1/2" and larger Mueller No.105-MAT
  - c. Check - 2" and smaller T-413-B
  - d. Check - Solder end S-413-B

Note: Check valves at pump discharge shall be in line spring loaded or swing design with weight or lever and spring.

2.5 PIPE SPECIALTIES

A. Manual Air Vents

1. Manual air vents shall be key-operated type installed where indicated on the drawings or as required for proper venting of equipment. Vents at top of vent chambers or coils shall be 1/4" brass cocks, Crane #2190 H or approved equal.

B. Pressure Regulating Valves

1. Pressure regulating valve on water fill lines serving hydronic systems shall be designed for 125 psig working pressure, set as required and shall be Watts Series U5B or approved equal. Relief valves shall be Watts Series 174A, ASME stamped or approved equal. Provide unions and pressure gauges upstream and downstream of pressure regulating valves.

C. Automatic Air Vents

1. Automatic air vents on water systems shall be Spirotherm, Sarco, Bell, and Gossett, or Amtrol equal to Spirotherm air release valve, 150 psi, and 250° operating temperature. Provide shut-off valve on each vent. Vents above suspended ceilings shall have 1/4" soft copper drain line extended indirect to nearest floor drain, service sink or drain line.

D. Strainers

1. Strainers shall be Mueller Steam Specialty Company, Inc., or approved equal, No. 351 for 2" and smaller and No. 758 for 2-1/2" and larger. Screens shall be stainless steel with 1/32" perforations for water. Provide valved blowdown connections on each strainer consisting of a gate valve set between two short nipples. Bush strainer outlet as required for 3/4" maximum connection. Provide a fine mesh start-up screen to be removed after system cleaning.

E. Flowmeter Fittings

1. Flowmeter fittings shall be Barco or approved equal Venturi type, or Dieterich Annubar type, or approved equal, brass or cast steel construction suitable for 150 psig working pressure and 250°F operating temperature and shall be equipped with brass quick-disconnect valves for connecting flowmeter. The fitting shall have a maximum head loss of one foot water gauge at design rate and shall have an accuracy of plus or minus 5 percent for water temperatures from 40°F to 215°F. Maximum meter reading shall be 50 inches water gauge.

F. Pressure Gauges

1. Gauges shall be Trerice, Ashcroft, Weiss, Winters, Crosby or Marsh equal to Trerice No. 450 series, liquid filled, 4-1/2" diameter case, bottom connected for easy reading. Dial shall have black letters on white background.
2. Pressure gauges shall be suitable for field calibration.
3. Each gauge shall be mounted within six feet of the floor on background or pipe mounted. Submit gauge locations and scale ranges for approval.
4. Provide Apollo or approved equal 1/4" ball valve where "gauge cocks" are indicated or required.
5. Select gauge such that at normal service the gauge pointer is at the middle of the scale range.

G. Thermometers

1. Thermometers shall be Moeller, Trerice, Weiss, Taylor, or approved equal. Thermometers shall be bi-metal type with adjustable angle, self-powered (no battery), 3/8" LCD digits display, Hi-impact ABS case, dual F&C switchable, temperature range - 40°F-300°F (-40°F-150°C), accuracy +/- 1% or 1°F, whichever is greater. Unit shall be complete with brass socket with extension necks for insulated pipes.
2. Thermometer (remote indicating type) shall be Weksler Series X, or approved equal, stainless steel casing, 4-1/2" dial, 0 degrees F to 120 degrees F reading, with Class 5A fully compensating capillary tubing (maximum length 25 feet), air temperature bulb and mounting bracket.

2.6 PIPE ANCHORS

- A. All pipe lines shall be anchored where specified herein, indicated on drawings and where required to prevent uncontrolled movement. Anchors shall be constructed of steel and plates, assembled by bolting or welding and secured to the building structure by means of clamps or welding. Structural members shall not be cut or drilled. Anchors shall prevent both axial and lateral movement of the lines. Anchor vertical pipes by means of clamps welded to pipe and secured to wall or floor construction. Submit details of anchors to Architect for approval.

- B. Anchor piping adjacent to flexible pipe connectors to prevent connector from expanding against its restraining bolts and also to keep the pipe on both sides of the connector in alignment.

## 2.7 EXPANSION (WATER SYSTEMS)

- A. Where expansion joints are indicated or required, select joints with a traverse of 150 percent of the pipe expansion from the ambient 40°F to the maximum system operating temperature.
- B. All expansion joints shall be suitable for minimum operating pressure and temperature of 150 psi and 300°F, respectively. Expansion joints 2" and larger shall have flanged ends, except when installed in copper pipe systems.
- C. Submit for approval manufacturer's shop drawings of each expansion joint provided depicting length of pipe, location of anchors and guides, calculated expansion offset and type of joint employed.
- D. Expansion joints shall be as herein specified:
  - 1. Flexible Ball Type - Barco Type N of Series 600.
  - 2. Corrugated Type - Flexonics "Low-Corr" joints for pipes 3" and larger. Flexonics Model H or HB for pipes smaller than 3".
  - 3. Slip Type - Flexonics "Slip Pakt" with anchor base.
  - 4. Loop Expansion Joints
    - a. Provide flexible hose expansion loop(s) as indicated on the contract drawings or as required to accommodate any thermal expansion, contraction or seismic movement of the piping system.
    - b. Flexible hose expansion loops shall be manufactured complete with two parallel sections of corrugated metal hose, compatible braid, 180 degree return bend, with inlet and outlet connections. Field fabricated loops shall not be acceptable.
    - c. Flexible loops shall be capable of movement in the  $\pm X$ ,  $\pm Y$ , and  $\pm Z$  planes.
    - d. Flexible hose expansion loops shall impart no thrust loads to system support, anchors or building structure.
    - e. For flammable liquid or gas service up to 4", flexible expansion loops shall be CSA / AGA certified.
    - f. All flexible hose expansion loops shall be manufactured in accordance with the documented manufacturers weld procedure specifications. The procedure qualification record shall be used to document the execution of this procedure and shall follow the general "guidelines" of ASME Section IX. Each individual welder shall conform to the in-house procedure qualification record and be qualified prior to each production lot. The testing of each individual welder shall be documented in a welding procedure qualification record.
    - g. Flexible hose expansion loops to be Metraloop as manufactured by The Metraflex Company or approved equal.
    - h. Corrugated Hose shall be stainless steel with 304 stainless steel braid.

- i. Fittings Materials of construction and end fitting type shall be consistent with pipe material and equipment/ pipe connection fittings. Copper fittings shall not be attached to stainless steel hose.
- j. Flexible hose expansion loops shall have a factory supplied, hanger / support lug located at the bottom of the 180 degree return.
- k. Flexible hose expansion loop(s) shall be furnished with a plugged FPT to be used for a drain or air release vent, and hanger lug at the bottom of the 180 degree return.

## 2.8 PIPE GUIDES

- A. Provide pipe guides where indicated on drawings or where required for proper installation of expansion loop. Limit use of guides with expansion loop to point shown or where required to prevent buckling of pipe whether indicated or not.
- B. Do not use pipe guides as pipe supports.
- C. Provide factory made cast semi-steel or other heavy fabricated steel consisting of bolted two-section outer cylinder and base with a two-section guiding spider welded or bolted tight to the pipe of sufficient size to clear pipe insulation and long enough to prevent over-travel of spider in cylinder. Furnish a guide sleeve of a length not less than the length of pipe expansion plus the spider length.
- D. When installed in cooling systems, guides shall permit the application of thermal insulation.

## 2.9 VIBRATION ISOLATION

- A. General
  - 1. Mechanical equipment and associated piping and ductwork shall be mounted on vibration isolators as specified and required to minimize transmission of vibrations and structure-borne noise to building structure or spaces.
  - 2. Select vibration isolating units for the lowest operating speed of equipment so designed that natural frequency of equipment and base mass is not less than 1.5 times the lowest operating frequency of the moving equipment but not a multiple or harmonic of the base frequency. Furnish vibration isolation producing a uniform loading and deflection even when equipment weight is not evenly distributed, and be stable during starting and stopping of equipment without excessive traverse and eccentric movement of equipment.
  - 3. Concrete pads under the isolation units shall be reinforced. Use concrete having a minimum compressive strength of 2500 psi and structural reinforcing bars conforming at ASTM A-615 Grade 60.
  - 4. The installed vibration isolation system for each floor or ceiling mounted item of equipment shall have a maximum lateral motion under equipment start up and shut down conditions of 1/4". Motions in excess shall be restrained by approved spring type mountings.
  - 5. All electrical connections, drain connections, etc., made to equipment which rests on vibration isolators, shall be sufficiently flexible to permit the equipment to be properly isolated.

6. The type of isolation, base, and minimum static deflection shall be as required for each specific equipment application, but no case less than that specified herein when supported on a solid concrete structural slab having a thickness of not less than 4". If vibration isolators with a deflection greater than the minimum specified are required to meet the noise criteria for the adjacent spaces, suitable isolation systems shall be submitted. Should vibration isolators installed for the equipment prove inadequate to prevent transmission of equipment vibrations to the building structure or limit equipment vibration originated noises in the building spaces to acceptable levels, the isolators shall be replaced with units having the largest deflection that can be practicably installed.
7. Spring and combination rail and spring isolation supports where designated in the schedule are indicated for equipment structurally built or supported on a rigid structural steel frame suitable for these types of isolation. Where these types of isolation are not suitable for the equipment construction or operation, the equipment shall be mounted on a structural steel base as herein specified.
8. Equipment affected by wind pressure or with operating weight different from installed weight shall have built-in adjustable vertical stops to prevent rising of equipment when weight is removed. Equipment containing liquid such as chilled water refrigeration units shall have vertical stops.
9. Inertia bases shall consist of a steel reinforced concrete slab cast into a welded structural steel channel frame. Frame shall be fabricated of sufficient strength to prevent distortion of any type during construction, and when the equipment is in operation. Equipment anchor bolts with bottom plates and pipe sleeves shall be preset. One-half inch steel reinforcing bars shall be placed on 6" center both ways in a layer 1-1/2" above the bottom of the base; bars shall extend inside channel frame flanges not less than 1".
10. Where required due to equipment configuration, the inertia block construction shall change and the concrete thickness shall increase as necessary for the proper mounting of the equipment. The weight of the inertia base shall be equal to or greater than the weight of the equipment supported. Additional weight necessary to reduce vibration or motion caused by the equipment's unbalanced forces to less the 1/32" movement shall be provided when necessary.
11. Concrete sub-bases not less the 4" shall be provided for all floor mounted mechanical equipment under another Division. Sub-bases shall rest on a structural floor and shall be reinforced with steel rods and interconnected with floor. A minimum clearance of 2" shall be provided between sub-bases and all inertia blocks, steel bases, and steel saddles with equipment in operation.
12. Each electric motor shall be mounted on the same foundation as the driven machine. Piping connections including strainers at pumps shall be supported on the same foundation as the pumps.
13. All exterior vibration isolation shall be hot dip galvanized.

B. Vibration Isolation Equipment

1. All isolation equipment shall be Mason Industries, Kinetics Noise Control, Vibration Eliminator, Amber/Booth, or Korfund equal to the following Mason Industries products:
  - a. Type II Mounting - Stable Springs. Mason Type SLF.



- b. Type IV Hanger - combination spring and double deflection neoprene element. Mason Type 30N.
- c. Type V Hanger - similar to Type IV with elevation holding device. Mason Type PC30N.
- d. Type VII Hose - Flexible pipe connector. Mason Type SFEJ or approved equal, with control rods.
- e. Type IX Base - structural steel base form for floating concrete base. Provide base of sufficient length to support pipes as indicated. Mason Type K.
- f. Type X Hose - Butyl rubber expansion joints with control rods.
- g. Type XIV Mounting - Steel spring hanger in a neoprene cup. Mason Type W30.

C. Application Of Isolation Equipment

<u>Item</u>	<u>Type</u>	<u>Deflection</u>
Pumps – Based-mounted (5 HP & Larger)	II & IX	0.75"
Piping – Hangers within 50ft of isolated equipment	V	1.50"
Piping – First two hangers near non-isolated equipment	IV	0.75"
Flexible Pump Connectors	VII	---
Pipe Expansion Joint	X	---
Ducts with Mechanical Rooms (over 2.5")	XIV	1.00"

2.10 MISCELLANEOUS EQUIPMENT

A. Test Plugs

1. Pressure and temperature test plugs where indicated or required shall be 1/4" npt fittings, suitable to receive either a 1/8" OD temperature or pressure probe. Fittings shall be solid brass with Nardel valve core, fitted with a color coded marked cap with gasket. The entire assembly shall be rated at 1000 psig. Provide two (2) pressure gauge adapters and two (2) 5" stem thermometers, 0°F to 220°F and 20°F to 130°F range. Plugs shall be as manufactured by Peterson Equipment Company, Inc., Richardson, Texas or Sisco plugs.

PART 3 - EXECUTION

3.1 CLEANING

- A. After completion of installation, thoroughly clean dirt, rust, loose scale, oils and grease, and other foreign matter from metal and insulated surfaces, painted or unpainted, specified under Division 23 of the specification.

- B. Clean all systems piping thoroughly of grease, metal shavings, welding beads, or other refuse. Flush piping by use of portable pump or separate water supply to prevent damage to existing or new system pumps. Before cleaning closed systems, all air handling coils and fan coil units shall be isolated by closing inlet and outlet valves and opening the by-pass valves. The system shall be filled with sufficient detergent and dispersant added to remove all dirt, oil, and grease. System shall be circulated for at least 48 hours after which a drain valve at the lowest point shall be opened and allowed to bleed while the system continues to circulate. Bleeding shall continue until water runs clear and all detergent is removed. A sample of the water shall be tested and, if PH exceeds the PH of the make-up water, draining shall be resumed. After flushing, clean strainers of debris, open coils and close by-passes. Remove dirty water filters and install new water filters. Turn over replacement bag filters to Owner. Refill and vent water systems being sure to add water after venting to completely fill system.

### 3.2 PIPING INSTALLATION

- A. Install piping without undue stress or strain in locations shown and run parallel to the lines of the building, except to grade them as specified in a neat and workmanlike manner using a minimum of fittings. Provide such fittings, valves, and accessories as may be required to meet the conditions of the installation. Contractor shall inform himself fully regarding any peculiarities and limitations of space available for installation of material under each section of specifications. Install piping to suit necessities of clearance with ducts, conduits, structure, and other work, and so as not to interfere with any passages or doorways and allow sufficient head room at all places. Use proper reducing fittings for changing piping sizes.
- B. Do not install piping through transformer vaults, elevator equipment rooms or other electrical or electronic equipment spaces. Do not route piping over electrical-distribution panels.
- C. Cut pipes accurately to measurements established in the field in a neat and workmanlike manner without damage or without forcing or springing. Perform cutting by means of an approved type of mechanical cutter of the wheel type where practicable. Ream pipe after cutting to remove all burrs.
- D. Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Carefully investigate the architectural, structural, and existing conditions affecting the work, and arrange such work accordingly, providing such fittings, and accessories as may be required to meet such conditions.
- E. Install unions and flanges where shown and on each side of all pieces of equipment and other similar items, and in such a manner that the unions or flanges can be readily disconnected. Do not place any union or flange in a location which will be inaccessible after completion of the project.
- F. Unions in steel pipe 2-1/2" and smaller for water service, shall be 250 lb. malleable iron brass, seat type. Use 150 lb. forged steel flanges for piping 3" and larger. Gaskets shall be 1/8" thick rated for 150 psi service at 250°F. Unions in copper pipe 2" and smaller shall be wrought copper with red bronze ring nut. Use 150 lb. ASME copper flanges for piping 2-1/2" and larger. Flanges and gaskets for use in steam and condensate systems shall be rated for system operating pressures.

- G. Use dielectric unions or couplings at all junctions of copper or brass piping and fittings with ferrous material to prevent electrolysis and galvanic corrosion.
- H. Joints between dissimilar piping material shall be made with appropriate adapters in accordance with the respective manufacturer's printed instruction and recommendations.
- I. Use reducing fittings, eccentric where required to prevent pocketing of air and water or both, to make changes in pipe sizes.
- J. Grade pipe minimum 1" in 40 feet to low points, unless otherwise specified or indicated. Provide drain valves at all low points.
- K. Automatic temperature control valves furnished by the control manufacturer shall be installed by the mechanical contractor under the control manufacturer's supervision.
- L. Install wells in hot water heating systems for automatic temperature control sensors. Exact locations and number of wells required shall be determined through coordination with the work required under Section "Automatic Temperature Control."
- M. All piping shall be so installed so that it will in no way be distorted or strained by expansion or contraction. Except as noted, all expansion and contraction shall be taken up by means of swing joints, loops, bends or long offsets. Swing joints made up with at least three fittings shall be provided in branches from mains to runouts. Size loops for the total pipe expansion without cold springing, but field cold spring one-half the pipe expansion corrected for ambient temperature.
- N. Brazing, bending, forming and assembly of refrigerant piping shall conform to ASME/ANSI B31.5.
- O. For installation of refrigerant piping, cut pipe to measurements established at the site and work into place without springing or forcing. Install piping with sufficient flexibility to provide for expansion and contraction due to temperature fluctuation. Where pipe passes through building structure, pipe joints shall not be concealed, but shall be located where they may be readily inspected. Install piping to be insulated with sufficient clearance to permit application of insulation. Install piping as indicated and detailed, to avoid interference with other piping, conduit, or equipment. Except where specifically indicated otherwise, run piping plumb and straight and parallel to walls and ceilings. Trapping of lines will not be permitted except where indicated. Provide sleeves of suitable size for lines passing through building structure. Braze refrigerant piping with silver solder complying with AWS A5.8. Inside of tubing and fittings shall be free of flux. Clean parts to be jointed with emery cloth and keep hot until solder has penetrated full depth of fitting and extra flux has been expelled. Cool joints in air and remove flame marks and traces of flux. During brazing operation, prevent oxide film from forming on inside of tubing by slowly flowing dry nitrogen through tubing to expel air. Make provisions to automatically return oil on halocarbon systems. Installation of piping shall comply with ASME/ANSI B31.5.
- P. Install refrigerant lines so that gas velocity in the evaporator suction line is sufficient to move oil along with gas to the compressor. Where equipment location requires vertical risers, line

shall be sized to maintain sufficient velocity to lift oil at minimum system loading and corresponding reduction of gas volume. Install a double riser when excess velocity and pressure drop would result from full system loading. Larger riser shall have a trap, of minimum volume, obtained by use of 90- and 45-degree ells. Arrange small riser with inlet close to bottom of horizontal line, and connect to top of upper horizontal line. Do not install valves in risers.

- Q. Provide refrigerant driers, sight glass liquid indicators, and strainers in refrigerant piping in accordance with FS 00-A-374 when not furnished by the manufacturer as part of the equipment. Install driers in liquid line with service valves and valved bypass line the same size as liquid line in which dryer is installed. Size of driers shall be determined by piping and installation of the unit on location. Install dryers of 50 cubic inches and larger vertically with the cover for removing cartridge at the bottom. Install moisture indicators in the liquid line downstream of the drier. Indicator connections shall be the same size as the liquid line in which it is installed.
- R. Locate strainers close to equipment they are to protect. Provide a strainer in common refrigerant liquid supply to two or more thermal valves in parallel when each thermal valve has a built-in strainer. Install strainers with screen down and in direction of flow as indicated on strainer's body.
- S. Install solenoid valves in horizontal lines with stem vertical and with flow in direction indicated on valve. If not incorporated as integral part of the valve, provide a strainer upstream of the solenoid valve. Provide service valves upstream of the solenoid valve, upstream of the strainer, and downstream of the solenoid valve. Remove the internal parts of the solenoid valve when brazing the valve.

### 3.3 LOOP EXPANSION JOINTS

- A. Install and guide per manufacturers' installation instructions and Mechanical Contractors Association of America "Guidelines for Quality Piping Installations".
- B. Flexible hose expansion loop return fitting shall be supported to allow movement.
- C. For steam applications, the operating pressure shall be based on burst pressure with an 8 to 1 safety factor.

### 3.4 WORKMANSHIP

- A. Cut pipes accurately to measurements established at structure. Install pipes without springing or forcing.
- B. Clear windows, doors, and other openings with all pipes and ductwork. Arrange pipes to permit expansion and contractions without misalignment or damage.
- C. During construction all openings in piping and equipment shall be closed with caps or plugs to keep out all foreign matter indicated.
- D. All piping in finished spaces shall be run concealed unless otherwise indicated.

### 3.5 PHASING

- A. The contractor shall schedule phasing to minimize the disruption of existing patient services. This phasing is essential to ensure a safe environment in patient care areas. Phasing shall include assurance for clean to dirty airflow, emergency procedures, criteria for interruption of protection, construction of roof surfaces, written notification of interruptions, and communication authority. Procedures must be developed for noise and vibration that will affect patients, and planned accordingly. The renovation areas shall be isolated from the occupied areas during construction using airtight barriers, and exhaust airflow shall be sufficient to maintain negative air pressure in the construction zone.

### 3.6 WELDING

- A. See Section 23 00 10.

### 3.7 SLEEVES AND PLATES

- A. See Section 23 00 10.

### 3.8 FLOW METER FITTINGS

- A. Locate and arrange piping, both upstream and downstream of fitting to conform to the manufacturer's published literature.
- B. When flow is measured in horizontal pipe, locate the connection nipples at or slightly above the horizontal centerline of the pipe to minimize the entrance of gases and impurities.
- C. Provide each fitting with an integral tab, or a metal tag or a stainless steel wire, extending outside the pipe covering, and stamp or print in a plainly visible position the manufacturer's name and address; the model number of the meter to which it is to be connected; the name, number or location of the equipment served; the specified rate of flow and the multiplier (including unity, where applicable) to be applied to the meter reading.
- D. Provide fittings with shut-off valves and with quick connecting hose fittings for portable meters.

### 3.9 TESTS

- A. The following tests shall be conducted by the Contractor and all piping shall be proven tight in the presence of the Architect or his representative. Notify Architect prior to tests. These tests shall be conducted before any insulation is installed and any insulation installed prior to test shall be removed. Provide all equipment and labor required. Tests shall be at least four hours in duration. Piping may be tested in sections as approved by the Architect. Tests shall be specified herein.
- B. All hot water heating, steam, and steam condensate piping shall be hydrostatically tested to 1-1/2 times the system working pressure or a minimum of 100 psig, whichever is greater.

- C. Upon completion of installation of refrigerant piping, test factory- and field-installed refrigerant piping in accordance with ASME B31.5. Use nitrogen or other suitable dry gas for testing. Ensure that test gas is eliminated from the system before charging. Minimum refrigerant leak field test pressure shall be as specified in ASHRAE 15, except that test pressure shall not exceed 150 psig on hermetic compressors unless otherwise specified as a low side test pressure on the equipment nameplate. If leaks are detected at time of installation or during warranty period, remove the entire refrigerant charge from the system, correct leaks, and retest system.
- D. After field charged refrigerant system is found to be without leaks or after leaks have been repaired on field-charged and factory-charged systems, evacuate the system using a reliable gage and a vacuum pump capable of pulling a vacuum of at least one mm Hg absolute. Evacuate system in accordance with the triple-evacuation and blotter method or in accordance with equipment manufacturer's printed instructions and charge system with proper volume of refrigerant.
- E. All pressure piping systems, unless otherwise specified herein, shall be filled with water and thoroughly flushed clean of foreign matter after erection and before connection of equipment.
- F. All centrifugal fans and centrifugal pumps shall be dynamically balanced and certified by an independent testing agency. The agency shall specialize in dynamic balancing of equipment and shall be able to demonstrate experience and expertise in dynamic documentation of all testing, including all test information as well as the certification. These documents shall become permanent records of the facility. The contractor shall be responsible to perform any alignment corrections and shall not be released of his contractual obligation until all equipment is certified to be dynamically balanced. All equipment requiring re-alignment shall be re-tested and certified. Submit name of testing company to the owner and engineer for approval.

END OF SECTION 23 00 50

## SECTION 23 05 33 - HEAT TRACING FOR HVAC PIPING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Section includes heat tracing for HVAC piping with the following electric heating cables:
  - 1. Self-regulating, parallel resistance.
  - 2. Control and monitoring modules.

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with Section 23 00 50.
  - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
  - 2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
  - 3. Include diagrams for power, signal, and control wiring.

### PART 2 - PRODUCTS

#### 2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

- A. Subject to compliance with requirements, provide products by one of the following:
  - 1. Thermon Americas Inc.
  - 2. Chromalox, Inc.
  - 3. Raychem; Tyco Thermal Controls.
- B. Comply with IEEE 515.1.
- C. Heating Element: Pair of parallel No. 16 AWG, tinned, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, non-heating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

- D. Electrical Insulating Jacket: Flame-retardant polyolefin.
- E. Cable Cover: Tinned-copper braid and polyolefin outer jacket with ultraviolet inhibitor.
- F. Maximum Operating Temperature (Power On): 150 deg F.
- G. Maximum Exposure Temperature (Power Off): 185 def F.
- H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- I. The heater shall be:
  - 1. Volts: 277
  - 2. Phase: 1
  - 3. Hertz: 60

## 2.2 CONTROLS

- A. Local Thermostat with Ground Fault Protection and Alarm Relay, Tracon Model GPT-130 or equal. Coordinate controls with Division 22.
  - 1. Remote bulb unit with adjustable temperature range set to activate heat trace at 40 deg F.
  - 2. Two-pole contactor switches up to 30 AMP heater loads.
  - 3. Integral 30ma GFEP.
  - 4. Enclosure shall be corrosion-resistant polycarbonate and NEMA 4X rated.
  - 5. The system shall sense ambient temperature in the general area of the traced pipe and turn heat tracing on when outside temperature is below 40 deg F and turn the heat tracing off when outside temperature is above 42 deg F.
  - 6. Remote interface provided via alarm relay. The system shall self test and alarm for no power, ground fault condition, GFEP function test failure, and damaged thermistor.

## 2.3 ACCESSORIES

- A. Provide cable installation accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
- B. Warning Labels: Vinyl-based and installed on the thermal insulation weather barrier. In accordance with the NEC, electrically heated pipelines and vessels are to be clearly identified "at frequent intervals along the pipeline or vessel". Caution labels should be placed at 10'-20' intervals or as required by local code.



## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.
  - 1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. The Division 26 contractor shall be responsible for power wiring and terminations between the electrical power system, the controls, and the heat trace power connections kits. The Division 23 contractor shall be responsible for control wiring, and conduit if required. The Division 23 contractor, in conjunction with Division 22, shall provide system layout drawing including cable, control location, sensors, and power connection points. Divisions will be required to coordinate with each other to meet specified installation requirements.
- B. Install electric heating cable across expansion, construction, and control joints according to manufacturer's written instructions; use cable-protection conduit and slack cable to allow movement without damage to cable.
- C. Install controls per manufacturer's written instruction.
- D. Electric Heating-Cable Installation for Freeze Protection for Piping:
  - 1. Install electric heating cables after piping has been tested and before insulation is installed.
  - 2. Install electric heating cables according to IEEE 515.1.
  - 3. Install insulation over piping with electric cables according to Section 23 07 00 "Mechanical Systems Insulation"
  - 4. Install warning tape on piping insulation where piping is equipped with electric heating cables.
- E. Set field-adjustable switches and circuit-breaker trip ranges by Division 26.

### 3.3 CONNECTIONS

- A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

### 3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
  - 2. Test cables for electrical continuity and insulation integrity before energizing.
  - 3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
- B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.
- C. Cables will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

### 3.5 PROTECTION

- A. Protect installed heating cables, including non-heating leads, from damage during construction.
- B. Remove and replace damaged heat-tracing cables.

END OF SECTION 23 05 33

## SECTION 23 05 93 - TESTING, ADJUSTING AND BALANCING FOR HVAC

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to the work specified in this section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. This section includes all labor and materials necessary to adjust, balance and test performance in accordance with design criteria and the equipment and components of systems included in Division 23 as follows:
  - 1. Air Distribution
  - 2. Water Distribution
  - 3. Equipment Performance
- B. Static pressure duct leakage tests will be performed under another section and shall be witnessed under this section.

#### 1.3 QUALIFICATIONS

- A. All work shall be performed under direct supervision of a qualified engineer. All instruments used shall be accurately calibrated and maintained in good working order. If requested, calibration tests of equipment to be used shall be performed in the presence of the Engineer or Owner's Representative.
- B. Work included in this section shall be performed by a pre-approved air and water balancing firm, who shall test, adjust, and balance the air and water systems for this project in accordance with NEBB or AABC Standard Procedures. Submit the name and qualifications of the air balance firm for approval within thirty (30) days after award of contract.
- C. Qualifications shall include the name of the technician that will be assigned to this project. The technician's qualifications shall be included and shall include successfully completed projects of similar size and complexity, references, and formal training.
- D. Acceptable air and water balance firms for this project shall include American Testing, Inc. and Baumgartner Incorporated.

- E. If the Contractor fails to submit the name of an acceptable agency within the specified time, the Architect will select a firm to accomplish the work, and the selection shall be binding at no additional cost to the Owner.
- F. All work shall be performed under direct supervision of a qualified engineer. All instruments used shall be accurately calibrated and maintained in good working order. If requested, calibration tests of equipment to be used shall be performed in the presence of the Engineer.

#### 1.4 TEST REPORT

- A. The balancing agency shall prepare a written report which shall include diagrams and description of procedures together with all recorded test data. The report shall be submitted in bound volumes for a permanent record. Submit four (4) copies of report. A set of contract drawings shall also be submitted. Drawings shall have each air device, flow fitting, pump, fan, and traverse location identified in red ink by a number which shall match identification numbers utilized in the balancing report. Commissioning checklists and functional performance test sheets shall be included in a separate section of final testing, balancing and commissioning report.
- B. Provide preliminary, informal reports to the CxA as systems are completed which also note any found deficiencies. Provide preliminary reports before Functional Performance Testing.
- C. Reports shall be submitted in accordance with requirements of Section 01 33 00 Submittal procedures.

#### 1.5 TEST PROCEDURE

- A. Systems may be tested in increments when approved by the Engineer.
- B. When testing and balancing involve the building temperature control systems, cooperate with the temperature control subcontractor to achieve the desired results. All setpoints shall be documented and included with test report.
- C. At the time of the final inspection, recheck in the presence and at the request of the Engineer not to exceed ten percent (10%) of the previously recorded readings from the certified report selected at random from the log by the Engineer.
- D. Permanently mark the settings of valves, dampers, and other adjustment devices so that adjustment can be restored if disturbed at any time. Do not permanently mark devices before final acceptance.
- E. Perform all tests in accordance with NEBB or AABC standard procedures. Any deviation from same must be approved by the Engineer.
- F. Should the basic system or any of its components fail to meet contract requirements, and thereby make the testing and balancing work invalid, notify the Engineer and stop the tests until such time that the failure is corrected.

## PART 2 - PRODUCTS

### 2.1 TESTING INSTRUMENTS

- A. Use instruments of equal or better quality than those described in the technical portions of Associated Air Balance Council National Standards for Testing and Balancing, Heating, Ventilating and Air Conditioning Systems, Fifth Edition, 1989.
- B. Instruments used for balancing air and water systems must have been calibrated within a period of six (6) months prior to balancing. Submit serial numbers, and dates of calibration of all instruments to be used prior to the start of work.
- C. Instrumentation shall include, as a minimum, the following items of equipment:
  - 1. Pressure gauges and fittings.
  - 2. Dry bulb and wet bulb thermometers.
  - 3. Contact pyrometer.
  - 4. Portable flow meter and, if required, orifice plates.
  - 5. Pitot tube and manometers.
  - 6. Alnor Velometer with attachments.
  - 7. Amprobe.
  - 8. Tachometer.
  - 9. Data Loggers.
  - 10. Blower door fan.

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. Within fifteen (15) days of receipt of notice to proceed, review plans and specifications of systems to be tested and balanced to confirm that the arrangement, instrumentation and balancing devices will permit the system to be balanced and tested in the manner described in this section and report to the Engineer any devices which need to be added or any phase of the design which needs to be modified to permit the fulfillment of this contract.
- B. Conduct balancing and testing in accordance with technical portions of the Associated Air Balancing Council--"National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems, Fifth Edition, 1989". Test procedures not in accordance or not described in the standards, i.e., variable air volume systems shall be approved by the Engineer in writing.
- C. Provide all labor, testing equipment, and materials required to conduct tests and balance systems.
- D. System shall be operated at least four (4) hours after stabilized operating conditions have been established before conducting capacity tests. Capacity and performance tests of equipment and systems shall be performed only after balancing is complete.

- E. Testing and balancing shall be performed for normal operation, as well as pandemic mode operation. Pandemic operation shall consist of two modes: Zone 1 and Zone 2. Zone 1 shall initiate modifications to VAV setpoints in the west side of Levels 4 and 5 to create a negative pressure suite and negative pressure patient rooms. Zone 2 shall initiate modifications to VAV setpoints in the entire floor of Levels 4 and 5 to create a negative pressure floor and negative pressure patient rooms. In each pandemic mode, the TAB agency shall work with the commissioning agent to verify each patient room, ante room, and the entire suite is under negative pressure, and the staff area is under positive pressure. Test reports shall be generated for each pandemic mode in addition to the normal operation mode.

### 3.2 AIR DISTRIBUTION SYSTEMS

- A. All air distribution systems including supply, return, outdoor air and exhaust ductwork shall be tested and balanced.
- B. Where the system cannot be properly balanced or equipment tested due to system deficiencies such as inability to properly adjust fan speeds, improperly sized motors, excessively noisy equipment, malfunctioning controls, excessively out of balance air distribution system branch runs, and similar item, furnish to the Engineer in writing a list of the deficiencies prior to the submission of the test report.
- C. Make openings in ducts required for pitot tube insertion and seal those openings with snap-in plugs. Neatly remove duct insulation as required for test. Replacement of insulation, after testing is completed, is included under Section 23 07 00.
- D. Specific testing and balancing procedures shall include:
  - 1. Test and adjust speed of all air apparatus.
  - 2. Test and record motor voltage and amperage.
  - 3. Make Pitot tube traverse of main ducts and obtain design air quantity at fans.
  - 4. Test and record system static pressures, suction, and discharge as well as pressure drops across each system element; ie, filters, coils, silencers, etc. Test and record static pressure and record settings of variable volume systems at pressure controllers. Record temperature control air pressure setpoints for minimum outside air, and maximum and minimum supply air volumes for all variable air volume systems.
  - 5. Test and adjust systems for design supply, outside, exhaust, and return air quantities.
  - 6. Test and record air entering and leaving conditions at air unit on both heating and cooling modes.
  - 7. Adjust all main and branch ducts for supply, return and exhaust air. Set and "mark" all volume dampers. Identify, test, and adjust each grille, register, and diffuser to within ten percent (10%) of design quantities except as noted below:
  - 8. For critical areas where differential pressures must be maintained:
  - 9. For positive zones, supply air shall be balanced within 0 to 10% high and exhaust/return 0 to 10% low. For negative zones, supply air shall be balanced within 0 to 10% low and exhaust/return 0 to 10% high.
  - 10. Verify operation of each room thermostat serving VAV terminal units over full range of heating and cooling to insure proper sequence of control of the VAV operator and reheat coil valve. Record results.

11. Field test maximum and minimum air volumes of all variable air volume terminal units and record final settings. Check factory settings of regulators and controllers before tests. Reset to the scheduled air volumes if required.
  12. Verify accuracy of all duct air monitors by duct traverse.
  13. Work in conjunction with the ATC Contractor and Engineer to establish maximum and minimum settings on all variable air volume fans.
  14. Check operation of variable air volume system controls. Test supply and return fan and outside air volumes by duct traverse at maximum, midpoint, and minimum air volumes to verify that programmed volume differential is maintained.
  15. A blower door test shall be performed for all All patient rooms to determine the air tightness of each room and locate any leaks that may cause difficulty maintaining negative pressure. Blower door shall be calibrated and the results shall be submitted to the engineer for review.
- E. Witness duct pressure tests as performed under Section 23 33 00. Submit with balancing report test condition and results for each section of duct tested. Include diagrams if required to define tested sections. Submit preliminary test data as soon as possible after testing.

### 3.3 WATER DISTRIBUTION SYSTEMS

- A. After the fluid piping system, including strainers, have been cleaned and controls are functioning as required under other sections of Division 23, adjust balancing devices installed for this purpose in accordance with the NEBB or AABC technical procedures to obtain the specified fluid flow or heat transfer rate.
- B. Use reading from system flow fittings, when installed, to determine flow quantity. Where fittings are not installed, determine liquid flow by measuring water pressure drop through devices with known Cv or pressure drop at specific flow rates. Use flow meter compatible with the type of fittings installed.
- C. Where liquid flow balancing cannot be accomplished due to system deficiencies such as excessive or lack of pumping head, inadequately sized motors, pressure drops not determinable or similar problems, prepare a list of such deficiencies and the suggested system modifications and furnish to the Engineer in writing and prior to submission of test report for necessary action.
- D. Specific testing and balancing procedures shall include:
  1. Check expansion tank for water level and tank pressure. Record pressure.
  2. Check all air vents for operation. Completely eliminate air from water systems.
  3. Set and adjust all pumps for proper delivery rates. Record all pump nameplate information. Record pump flow, water temperature, inlet and outlet pressures, and motor voltage amps, and rpm.
  4. Set and adjust water flow in all piping system branches and risers and record flow.

### 3.4 EQUIPMENT PERFORMANCE

- A. Conduct performance tests only after the air and water systems have been balanced and the proper flow rates established.
- B. Test and record capacity of heat transfer equipment including all coils. Air side and water side capacities must agree within five percent (5%) of each other. Include the manufacturer's rated capacity at the test operating conditions with the report. Perform tests where possible at design conditions. If tests are not performed under design conditions, interpolate results to determine capacity at full load operating conditions.
- C. Calculate efficiency of pumps and fans by recognized methods using test data.
- D. Test refrigeration equipment to determine heat extracted from or heat added to the building by the equipment and the heat ejected from the device. Record date, time and outside weather conditions, including ambient dry bulb, wet bulb, wind speed and direction, cloud cover, rain, and any special conditions pertinent to the test.
- E. Perform functional performance tests (FPTS) and document on FPT forms for:
  - 1. VAVs (sample strategy)
  - 2. AHUs
  - 3. Fans
  - 4. Pumps
  - 5. Other equipment and/or systems as required

### 3.5 COMMISSIONING RESPONSIBILITIES

- A. With respect to HVAC commissioning, the TAB agency shall:
  - 1. Include cost for HVAC commissioning requirements in the quoted price.
  - 2. Attend commissioning meetings scheduled by the CA prior to, and during, on-site TAB work being done.
  - 3. Submit proposed TAB procedures to the CA and mechanical engineer for review and acceptance.
  - 4. Attend the TAB planning meeting scheduled by the CA. Be prepared to discuss the procedures that shall be followed in testing, adjusting and balancing the HVAC system.
  - 5. At completion of the TAB work, submit the final TAB report to the construction manager, with copies to the Owner, CA and mechanical engineer.
  - 6. Participate in verification of the TAB report by the CA for verification or diagnostic purposes. This will consist of repeating a sample of 10% of the measurements contained in the TAB report as directed by the CA.

END OF SECTION 23 05 93



## SECTION 23 07 00 - MECHANICAL SYSTEMS INSULATION

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. The general provisions of the Contract, including General and Supplementary Conditions and Division 01 specifications, apply to the work specified in this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Work included in this section consists of furnishing all labor, equipment, materials and accessories, and performing all operations required, for the correct fabrication and installation of thermal insulation applied to the following piping, equipment, and duct systems, in accordance with applicable project specifications and drawings:
  - 1. Heating systems (steam, steam condensate, hot water) 105°F and up.
  - 2. Cooling systems (chilled water, refrigerant), 0°F to 60°F.
  - 3. Air handling ductwork, shafts, and plenums, to 1200°F.
  - 4. Heat exchangers.
  - 5. Converters.
- B. Work excluded in this Section are the following:
  - 1. Thermal building insulation.
  - 2. Sound absorbing duct lining.
- C. The requirements of Section 23 00 10, Mechanical General Provisions, shall apply to the work specified under this Section.

#### 1.3 DEFINITIONS

- A. The k factor means the number of British thermal units of heat transmitted per (sq. ft.) Fahrenheit temperature difference through a material with flat, parallel sides one inch (1") apart. The material shall be tested and rated according to ASTM Test Method C-177.
- B. The term "Mineral Fiber" as defined above specifications includes fibers manufactured of glass, rock or slag processed from a molten state, with or without binder.
- C. Unless otherwise specified, the term concealed, as used in this specification, shall include all furred spaces, accessible pipe and duct shafts, and spaces above suspended ceilings.

- D. Unless otherwise specified, the word exposed shall refer to all work other than "concealed" work.

#### 1.4 REFERENCES

- A. Thermal insulation materials shall meet the property requirements of one or more of the following American Society for Testing of Materials (ASTM) specifications as applicable to the specific product or use:
  - 1. ASTM C 533-07: Specification for Calcium Silicate Block and Pipe Thermal Insulation.
  - 2. ASTM C 547 "Standard Specification for Mineral Fiber Pipe Insulation"
  - 3. ASTM C 553 "Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications"
  - 4. ASTM C 585 "Standard Practice for Inner and Outer Diameters or Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System)"
  - 5. ASTM C-591 "Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation"
  - 6. ASTM C 612 "Standard Specification for Mineral Fiber Block and Board Thermal Insulation"
  - 7. ASTM C 795 "Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel"
  - 8. ASTM C 1126-04: Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation.
  - 9. ASTM C 1136 "Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation"
  - 10. ASTM C 1290 "Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts"
  - 11. ASTM G-21 "Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi" (fungi resistance section only)
  - 12. ASTM G 22 "Practice for Determining Resistance of Plastics to Bacterial (bacteria resistance section only)

#### 1.5 SYSTEM PERFORMANCE

- A. Insulation materials furnished and installed hereunder should meet the minimum economic insulation thickness requirements of the North American Insulation Manufacturers' Association (NAIMA) to ensure cost-effective energy conservation performance. Alternatively, materials should meet the minimum thickness requirements of Standard 90.1, "Energy Standard for Building Except Low Rise Residential Buildings," of the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor. In no case shall the insulation thickness be less than that specified herein.
- B. Insulation materials furnished and installed hereunder shall meet the fire hazard requirement of any one of the following specifications:
  - 1. American Society of Testing of Materials ASTM E 84

2. Underwriters' Laboratories, Inc. UL 723
3. National Fire Protection Association NFPA 255

#### 1.6 FIRE RESISTANCE

- A. Except for materials which are subsequently exempted, all materials used as part of the thermal insulation shall have a fire hazard rating not to exceed twenty-five (25) for flame spread and fifty (50) for fuel contributed and smoke developed.
- B. Test factory assembled materials as assemblies.
- C. Determine ratings by the Standard Method of Test for Surface Burning Characteristics of Building Materials, ASTM E-84 or NFPA No. 255.
- D. The following will be required to establish that fire hazard ratings for materials proposed for use do not exceed those specified: (1) label or listing by Underwriter's Laboratories, Inc., (2) certified test report from an approved testing laboratory.
- E. The following materials are exempt from the foregoing Fire Resistant Rating:
  1. Jackets of canvas, PVC and nylon.
  2. Polyurethane, polystyrene, cork and flexible, closed-cellular insulation.
  3. Nylon anchors for securing insulation to ducts and equipment.
  4. Factory pre-molded one (1) piece PVC fitting and valve covers.

#### 1.7 QUALIFICATIONS

- A. Materials submitted shall be standard products of a manufacturer who has been engaged in the production of the products for not less than three (3) years.
- B. The installing sub-contractor shall have at least five (5) years of successful installation experience on projects with similar insulation products.

#### 1.8 QUALITY ASSURANCE

- A. Insulation materials and accessories furnished and installed hereunder shall, where required, be accompanied by manufacturers' current submittal or data sheets showing compliance with applicable specifications listed in Section 1.4 above.
- B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.

#### 1.9 SUBMITTALS

- A. Provide shop drawings in accordance with Section 23 00 10 and the General Requirements which shall include all insulation, jackets, finishes, corner beads, etc. Shop drawings shall

additionally describe each system or component to be insulated, insulation type and thickness, and method of installation.

#### 1.10 DELIVERY AND STORAGE OF MATERIALS

- A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.
- B. The contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The contractor shall also use all means necessary to protect work and materials installed by other trades.
- C. If any insulation material has become wet because of transit or job site exposure to moisture or water, the contractor shall not install such material, and shall remove it from the job site. An exception may be allowed in cases where the contractor is able to demonstrate that wet insulation when fully dried out (either before installation, or afterward following exposure to system operating temperatures) will provide installed performance that is equivalent in all respects to new, completely dry insulation. In such cases, consult the insulation manufacturer for technical assistance.

#### 1.11 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 00 50 and Section 23 00 10.
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

#### 1.12 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

### PART 2 - PRODUCTS

#### 2.1 GENERAL

- A. All insulating materials, including adhesives, jackets and coatings, to be used on the project must be delivered to the building in the manufacturer's unopened container and must bear the manufacturer, brand and description of material.
- B. After the necessary tests have been conducted to prove the water and air systems tight, all piping, ductwork and equipment to be insulated shall be thoroughly cleaned and then covered. Insulation materials shall be the product of Owens Corning, Knauf, Manville or Armstrong equal to the products specified herein.
- C. Molded pipe insulations shall be manufactured to meet ASTM C 585 and ASTM C 547.
- D. Light density glass fiber duct wrap shall be manufactured to meet the requirements of ASTM C 1290.
- E. Heavy density glass fiber duct board shall be manufactured to meet the requirements of ASTM C 612.

## 2.2 TYPES OF INSULATION:

- A. Refer to insulation type schedule on drawings.

## 2.3 ADHESIVES, SEALERS AND COATINGS

- A. Provide all adhesives, sealers, vapor barrier coatings etc., compatible with the material to which they are applied. They shall not corrode, soften or otherwise attack such material in either the wet or dry state and must be suitable for the service temperatures.
- B. Any cement, sealer or coating used shall be resistant to vermin and mold and shall be durable. It shall not discolor on aging; and where applied on the final surface of the insulation, it shall be light in color and be capable of being painted.
- C. Adhesives, coatings and compounds shall be equal to the following:
  - 1. Vapor barrier adhesive for sealing joints on pipe and duct insulation - Foster 85-75.
  - 2. Adhesive for installing duct insulation - Foster 85-20 and 81-91.
  - 3. Insulating cement - Owens Corning No. 110

## 2.4 FITTINGS AND VALVE COVERS

- A. Pipe fittings and valves shall be insulated with Owens Corning PVC pre-molded one (1) piece PVC insulated fitting cover and factory pre-cut insulation. Fittings shall have edges of one (1) piece cover sealed with Owens Corning vapor barrier pressure sensitive tape.

## 2.5 METALLIC COMPONENTS

- A. Staples shall be outward clinching type of Type 304 or Type 316 stainless steel.

- B. Bands shall be galvanized steel, aluminum, brass, or nickel-copper alloy, of three-quarter inch (3/4") nominal width. The band thickness, exclusive of coating, shall be not less than five thousandths inch (0.005") for steel and nickel copper alloy, seven thousandths inch (0.007") for aluminum, and one hundredth inch (0.01") for brass.
- C. Wire shall be 14-gauge, nickel-copper alloy or copper clad steel, or 16-gauge, soft annealed, galvanized steel.
- D. Wire netting used for exposed surfaces of insulation that is to be cement finished shall be 22-gauge, one-inch (1") galvanized mesh, with continuous 26-gauge galvanized steel corner beads having two and one-half inch (2-1/2") wings.
- E. Protect external corners on insulation of ducts and equipment exposed in occupied spaces by corner beads two inches (2") by aluminum adhered to heavy duty Kraft paper.
- F. All exterior piping shall be additionally covered with a sixteen mil (16 mil) (0.4mm) embossed aluminum or stainless-steel weatherproof jacket. Jacketing shall be Childers Lock-on type with factory applied poly kraft moisture barrier. Jackets are to be fabricated with continuous Z-lock on the longitudinal seam and sections shall be joined with factory fabricated butt strap and sealant. Fitting shall be insulated and weatherproofed using similar materials.
- G. Where indicated, all piping shall be covered with UV resistant Owens Corning or Zeston PVC jacketing. Installation shall be in accordance with the manufacturer's limitation with regard to surface temperature and thermal expansion. Fittings shall be insulation as prescribed above, jacketed with pre-formed fittings covers matching the outer jacketing.

## 2.6 INSULATION SCHEDULE:

- A. Refer to insulation schedule on drawings.
- B. Insulation thickness may be reduced on ducts with internal lining in an amount equal to the thickness of the lining. Refer to drawings for internal lining locations.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
  - 1. Verify that systems to be insulated have been tested and are free of defects.
  - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

### 3.3 GENERAL

- A. All insulation shall be installed by skilled workmen regularly engaged in this type of work.
- B. Insulation shall be continuous at all hangers, sleeves and openings. Vapor seals shall be provided for all cold surfaces and shall be continuous.
- C. Arrange to permit expansion and contraction without causing damage to insulation or surface.
- D. Actual insulation thickness must be at least equal to the minimum specified in the schedule. Where the manufacturers' rated or nominal thickness is less than the minimum specified, a thicker material or more layers will be requested so that the stated minimum thickness will be attained or exceeded.
- E. Install insulation materials in a first class manner with smooth and even surfaces. Scrap pieces of insulation shall not be used where a full length section will fit.
- F. Unless otherwise specified herein, the application of all insulation materials, accessories and finishes shall be in accordance with the manufacturer's published recommendations.
- G. Insulation materials shall not be applied until all surfaces to be covered are clean and dry; all foreign material, such as rust, scale, dirt, etc., has been removed; and, where specified, surfaces have been painted. Insulation shall be clean and dry when installed and during the application of any finish. The insulation on pipe fittings, valves and pipe joints shall not be installed before the piping is tested and approved.
- H. Omit insulation on the following unless directed otherwise:
  - 1. Traps and pressure reducing valves, relief piping from safety valves, and unions, flanges and expansion joints on hot water heating system.
  - 2. Exposed ducts in air-conditioned spaces.
- I. Replace and repair insulation disturbed by testing and balancing procedures.

### 3.4 PIPE INSULATION

- A. High density pipe saddles shall be provided at all points of support as hereinbefore specified in Section 23 00 10.

- B. Insulate all valves and strainers. Use pre-molded covers and factory precut insulation where applicable. Unions and flanges shall not be insulated except on cold service.
- C. Insulate valves up to and including bonnets, except for cold water valves which shall be insulated over packing nuts in a manner to permit removal for adjustment and repacking.
- D. Insulate strainers in a manner to permit removal of the basket without disturbing the insulation of the strainer. Obtain Engineer's approval of installation method.
- E. Application - Types I Insulation
  1. Insulate all pipes in a neat and workmanlike manner. Seal all longitudinal laps of jackets and staple every six inches (6"). Where the piping operates below ambient temperature, the staples shall be coated with vapor barrier adhesive. All butt joints shall be wrapped with a three inch (3") minimum wide strip of jacketing material securely sealed in place.
  2. Insulate valves and fittings with pre-cut blanket type fiberglass insulation and PVC covers as specified. Insulation shall be of the same thickness as that on adjoining pipe. The ends of the insulation shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe covering tufted and tucked in, fully insulating the pipe fitting. The one (1) piece PVC fitting cover shall then be secured by stapling, tack fastening, banding or taping the ends to the adjacent pipe covering. The circumferential edges of cover shall be color matching tape. The tape shall extend over the adjacent pipe insulation and overlap itself at least two inches (2") on the downward side.
  3. Where fittings are operating above ambient they may, in lieu of the preceding paragraph, be covered with a three hour (3 hr.), hydraulic setting, combination insulating and finishing cement having k factor not greater than 0.87 at a mean temperature of two hundred degrees Fahrenheit (200° F). The thickness of this cement shall be such that the surface is substantially flush with the pipe covering. Where the insulation terminates at a fitting that is not covered, the end of the insulation shall be beveled off with this same cement. All fittings insulated in this manner shall be covered by a fabric jacket as specified, which shall be cemented down with lagging adhesive.
  4. Where expansion joints are required to be insulated, they shall be covered with readily removable sections of insulation of same composition and thickness as provided for adjacent piping.
- F. Application - Type II Insulation
  1. The material shall be slit lengthwise to permit installation or slipped over pipe before connections are made.
  2. All joints and seams must be thoroughly bonded, both mechanically and hermetically, by the adhesive recommended by the insulation manufacturer. Also, the manufacturer's recommendations shall be followed as to the adhesive to use where the insulation needs bonding to metal or other material used for any surface treatment where a finish coat of paint is required.
  3. All penetrations of the insulation must be thoroughly sealed so that the insulation itself will form a complete vapor barrier. Wherever the insulation terminates, the edges shall be sealed to the metal.



### 3.5 DUCT INSULATION

- A. Provide accessories as required to prevent distortion and sagging of duct insulation. Provide welded pins, adhesive clips and wire ties as recommended by the manufacturer and directed by the Engineer.
- B. Insulation shall cover all standing seams and metal surface. Provide corner beading on all exposed ducts.
- C. Staples shall be sealed to maintain vapor barrier.
- D. Neatly cut insulation at dampers, temperature control sensors, and controllers. Butter exposed edges with approved mastic coating. Extend insulation to cover pipe return bends for air terminal unit reheat coils.
- E. Application - Type IV Insulation:
  - 1. Insulation shall be cut slightly longer than perimeter of duct to insure full thickness of corners. All insulation shall be applied with edges tightly fastened with staples. Tape the stitched seam with three inch (3") wide pressure sensitive tape. The insulation shall be additionally secured to the bottom of all square ducts eighteen inches (18") or wider by means of welded pins and speed clips. The protruding ends of the pins shall be cut off flush after the speed clips have been applied. The vapor barrier facing shall be thoroughly sealed where the pins have pierced through with a tape of the same material by applying a vapor barrier adhesive to both surfaces as recommended by the manufacturer.
  - 2. All joints and penetrations of the vapor barrier shall be sealed with three inch (3") pressure sensitive tape. All cuts or tears shall be sealed with strips of the aluminum foil tape.
- F. Application - Type V Insulation:
  - 1. All insulation shall be applied with edges tightly butted. Insulation shall be impaled on stick clips or pins welded to the duct and secured with speed clips. Spacing of pins shall be as required to hold insulation firmly in place but not less than one (1) pin per square foot (FT<sup>2</sup>), and pins shall be placed within three inches (3") of each corner of insulation. All joints and penetrations of the vapor barrier shall be sealed with a three inch (3") wide strip of the same material, applied with Foster 85-75, or to both surfaces as recommended by the adhesive manufacturer.
  - 2. If, through space or size restriction or other causes, the welded pin method is impossible, the insulation shall be secured to the duct with adhesive such as Foster 81-91 or equal. The adhesive shall cover the entire surface of the sheet metal when applied to underside of horizontal duct but may be applied in strips or spots for application to top and sides with a minimum of fifty percent (50%) coverage.
- G. Application – Type XIII Insulation
  - 1. Apply a brush coat of manufacturer's recommended adhesive to dry, clean, metal surface covering an area equal to the size of one (1) sheet. Apply a brush coat of adhesive to the back of the sheet. Once the adhesive is tacky, position the sheet so that the edges overlap the previously installed sheets by one eighth inch (1/8"). Apply

- pressure to adhere sheet. Compress butt edges into place. Spread joints and coat with adhesive. Apply adhesive to the butt edges of the insulation.
2. Apply manufacturer's recommended seal tape to all joints and exposed edges. Finish by applying even pressure using a roller.

### 3.6 EQUIPMENT INSULATION:

- A. Cut or score insulation to fit shape and contour of equipment. Stagger all joints.
- B. Provide permanently fastened angles or plates, where required to support insulation.
- C. Do not cover nameplates. Cut back the insulation and line edges with 26-gauge galvanized steel.
- D. Application - Type VI & IX Insulation
  1. Insulation shall be applied with staggered joints firmly butted and joined. The insulation shall be held in place by steel bands. Bands shall be spaced on not over twelve inch (12") centers. All joints and voids shall be filled with cement, well trowelled into openings. Apply over the insulation surface one inch (1") galvanized wire netting laced together at all edges and wired to the steel bands with 16-gauge soft annealed wire. Over this shall be applied a one-half inch (1/2") thick layer of insulating cement applied in two (2) layers. Install metal corner beads at all corners and edges to provide a permanent installation.
- E. Application - Type VIII Insulation
  1. Apply a brush coat of manufacturer's recommended adhesive to dry, clean three-quarter inch (3/4") high v-rib, stand-off expanded metal lath to provide an air space between the covered surface and insulation, covering an area equal to the size of one (1) sheet. Apply a brush coat of adhesive to the back of the sheet, except for a one-half inch (1/2") wide border around the edges. After adhesive on metal ribs and sheet has dried to a non-tacky state, position sheet so that the edges overlap the previously installed sheets by one eighth inch (1/8"). Apply light pressure to adhere a spot in the center of the sheet only and compress butt edges into place. Spread joints and coat with adhesive.

### 3.7 FINISHES

- A. PVC jacket shall be provided on all interior exposed piping, equipment, and ductwork herein specified to be insulated.
- B. Where PVC jacket is to be installed on piping, installation materials and procedures shall be in accordance with the manufacturer's recommendations.
- C. All pipes exposed to the weather shall be covered with aluminum jacket minimum 0.016 inch thick kept in place with aluminum bands 12 inches on center. Longitudinal seams shall be on

underside of pipe and horizontal joints shall be lapped 3 inches with aluminum bands at edge of overlap.

END OF SECTION 23 07 00

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## SECTION 23 08 00 - COMMISSIONING OF HVAC SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. The contractor is responsible for commissioning the systems and components in this section.
- B. The commissioning process requirements are outlined in Section 01 91 13 General Commissioning Requirements. Contractor is responsible for complying with all requirements listed therein.

END OF SECTION 23 08 00

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## SECTION 23 09 00 - INSTRUMENTATION AND CONTROL FOR HVAC

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- B. Related Sections include the following:
  - 1. Section 23 00 50 for measuring equipment that relates to this Section.

#### 1.3 DEFINITIONS

- A. DDC: Direct digital control.
- B. I/O: Input/output.
- C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- D. MS/TP: Master slave/token passing.
- E. PC: Personal computer.
- F. PID: Proportional plus integral plus derivative.
- G. RTD: Resistance temperature detector.

#### 1.4 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
  - 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.

2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
  - a. Water Temperature: Plus or minus 1 deg F.
  - b. Water Flow: Plus or minus 5 percent of full scale.
  - c. Water Pressure: Plus or minus 2 percent of full scale.
  - d. Space Temperature: Plus or minus 1 deg F.
  - e. Ducted Air Temperature: Plus or minus 1 deg F.
  - f. Outside Air Temperature: Plus or minus 2 deg F.
  - g. Dew Point Temperature: Plus or minus 3 deg F.
  - h. Temperature Differential: Plus or minus 0.25 deg F.
  - i. Relative Humidity: Plus or minus 5 percent.
  - j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
  - k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
  - l. Airflow (Terminal): Plus or minus 10 percent of full scale.
  - m. Air Pressure (Space): Plus or minus 0.01-inch wg.
  - n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
  - o. Carbon Monoxide: Plus or minus 5 percent of reading.
  - p. Carbon Dioxide: Plus or minus 50 ppm.
  - q. Electrical: Plus or minus 5 percent of reading.

## 1.5 SEQUENCE OF OPERATION

- A. Refer to drawings for sequence of operation.

## 1.6 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
  1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation



- equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
  - 2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
  - 3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- 1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
  - 2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
  - 3. Wiring Diagrams: Power, signal, and control wiring.
  - 4. Details of control panel faces, including controls, instruments, and labeling.
  - 5. Written description of sequence of operation.
  - 6. Schedule of dampers including size, leakage, and flow characteristics.
  - 7. Schedule of valves including flow characteristics.
  - 8. Coordinated list of air terminal units showing unique ID, room location, room served, constant volume or VAV, CO2 control or not, and occupancy control or not.
  - 9. DDC System Hardware:
    - a. Wiring diagrams for control units with termination numbers.
    - b. Schematic diagrams and floor plans for field sensors and control hardware.
    - c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
  - 10. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
  - 11. Controlled Systems:
    - a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    - b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    - c. Written description of sequence of operation including schematic diagram.
    - d. Points list.
- C. Samples for Verification: For each color required, of each type of thermostat or sensor cover.

## 1.7 INFORMATIONAL SUBMITTALS

- A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

- B. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks.
- C. Qualification Data: For Installer and manufacturer.
- D. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
- E. Field quality-control test reports.

#### 1.8 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
  - 1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
  - 2. Interconnection wiring diagrams with identified and numbered system components and devices.
  - 3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
  - 4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
  - 5. Calibration records and list of set points.
- B. Software and Firmware Operational Documentation: Include the following:
  - 1. Software operating and upgrade manuals.
  - 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
  - 3. Device address list.
  - 4. Printout of software application and graphic screens.
  - 5. Software license required by and installed for DDC workstations and control systems.

#### 1.9 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Maintenance Materials: One thermostat adjusting key(s).

#### 1.10 QUALITY ASSURANCE

- A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with ASHRAE 135 for DDC system components.

1.11 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
- B. System Software: Update to latest version of software at Project completion.

1.12 COORDINATION

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
- B. Coordinate equipment with Section 28 16 00 "Intrusion Detection" to achieve compatibility with equipment that interfaces with that system and with building master clock.
- C. Coordinate equipment with Section 28 13 00 "Access Control" to achieve compatibility with equipment that interfaces with that system.
- D. Coordinate equipment with Section 27 53 13 "Clock Systems" to achieve compatibility with equipment that interfaces with that system.
- E. Coordinate equipment with Section 28 461 9 "PLC Electronic Detention Monitoring and Control Systems" to achieve compatibility with equipment that interfaces with that system.
- F. Coordinate equipment with Section 26 09 43.13 "Addressable-Fixture Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" to achieve compatibility with equipment that interfaces with that system.
- G. Coordinate equipment with Section 28 31 11 "Digital, Addressable Fire-Alarm System" to achieve compatibility with equipment that interfaces with that system.
- H. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.
- I. Coordinate equipment with Section 26 09 13 "Electrical Power Monitoring and Control" to achieve compatibility of communication interfaces.
- J. Coordinate equipment with Section 26 24 16 "Panelboards" to achieve compatibility with starter coils and annunciation devices.

- K. Coordinate equipment with Section 26 24 19 "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.
- L. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 03 30 00 "Cast-in-Place Concrete."

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
  - 2. Manufacturers: Subject to compliance with requirements, provide products by Johnson Controls, Inc.

### 2.2 CONTROL SYSTEM

- A. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics. Control system shall be provided by Johnson Controls, Inc.

## PART 3 - EXECUTION

- A. Provide examination and installation.

END OF SECTION 23 09 00

## SECTION 23 21 23 - HYDRONIC PUMPS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications Sections, apply to this section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. This section includes pumps for heating, ventilating and air conditioning systems as indicated on the drawings and described herein.
- B. Types of pumps specified in this section include the following:
  - 1. End Suction Base Mounted
  - 2. Closed Coupled Inline

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with Section 23 00 50.
  - 1. Include construction details, materials descriptions, dimensions of individual components and profiles, and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include plans, elevations, sections, and mounting or attachments details.
  - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams for power, signal, and control wiring.
  - 5. Operation and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 GENERAL

- A. Pump capacities shall be as scheduled on the drawings.

## HYDRONIC PUMPS

- B. Reference Motor Specification Section 23 00 10 for efficiency and construction compliance. The motors shall be ODP design.
- C. Data submitted for approval shall include pump speed and characteristic curves for performance of the impeller selected. Curves shall indicate capacity vs. head, NPSHR, efficiency and brake horsepower for the full range, from shut-off head to free delivery. Manufacturers' pumps may be considered only if pump efficiencies are equal or greater than the basis of design.
- D. Vibration isolation shall be provided as specified in Section 23 00 50.
- E. Base ells or support shall be provided under piping risers from pump and risers shall further be supported by calibrated spring hangers. Where pump arrangement precludes the use of base elbows or comparable supports, piping shall be supported by means of spring-loaded hangers calibrated for the specific use. Pump isolation bases shall be sized to accommodate the support ells.
- F. Pumps shall be selected so that the operating point on the selected impeller curve will be at or to the left of, and not more than 5% below, the point of maximum efficiency. Impeller size for specified duty shall not exceed 90% of volute diameter.
- G. Pumps shall be provided with motors conforming to Section 23 00 10. Motors shall not exceed 1750 rpm unless noted on pump schedule. Pumps shall be non-overloading with respect to nameplate horsepower throughout the impeller performance curve, unless specifically noted on pump schedule.
- H. Suction diffuser, where indicated, angle or straight pattern shall be rated for 175-psig. Construction shall be cast-iron body, end cap, and pump inlet fitting, with bronze startup and stainless permanent strainers; bronze or stainless-steel straightening vanes; drain plug, and factory or field-fabricated support.
- I. The flush line to the mechanical seal shall be equipped with a 50 micron cartridge filter or when the pump differential exceeds 30 PSIG, a cyclone separator can be utilized with a signal flow indicator. The mechanical contractor shall change the filters after the system has been flushed and on a regular basis until the pumps are turned over to the Owner. At final acceptance new filters shall be provided.
- J. All flexibly coupled pumps shall be aligned with a laser alignment system. Laser alignment reports for each pump shall be turned over to the Owner in the pump O&M package.

## 2.2 TYPE "A" PUMP (END-SUCTION BASED-MOUNTED)

- A. Pump shall be a centrifugal horizontal frame-mounted end suction type. Pumps shall be capable of achieving performance as scheduled.
- B. The casing shall be of the end suction design with centerline discharge outlet in order to facilitate case venting. The casing shall have tapped and plugged holes for priming, draining,

## HYDRONIC PUMPS

and gauges. The casing shall be constructed of cast iron for working pressures below 175 psig at 150°F (125 psig ANSI flange rating) and Ductile Iron for working pressures to 375 psig at 150°F (250 psig ANSI flange rating.) The casing bore shall be large enough to allow "back pullout" of the impeller without disturbing the casing or suction and discharge piping. For suction piping diameters of 2" or less and discharge piping diameters of 1.5" or less, the suction and discharge connections shall be NPT threaded. For suction piping diameters of 2.5" or greater and discharge piping diameters of 2" or greater, the suction inlet shall be a flat-faced flange connection and the discharge outlet shall be a bolt through flange connection. Flange connections shall be ANSI 125 psig rated. The casing shall be supported by the power frame.

- C. The impeller shall be of the enclosed type, vacuum cast in one piece and constructed of bronze, ASTM B584. The impeller shall be finished, the exterior being turned and the interior being finished smooth and cleaned. The impeller shall be dynamically balanced. The impeller shall be keyed to the shaft, fastened with a washer, gasket and capscrew.
- D. The pump casing shall be fitted with a case wear ring to minimize abrasive and corrosive wear to the casing. The case wear ring shall be bronze, ASTM B62, of the radial type, press fitted into the casing.
- E. Shaft sealing shall be accomplished by means of a John Crane Mechanical seal suitable for 225°F operation. The seal shall have a Tungsten carbon seat, carbon washer, Buna-N elastomers, and stainless steel metal parts. The mechanical seal shall be internally flushed.
- F. The impeller shall be direct-coupled to the power frame shaft. The shaft shall be machined to provide an impeller keyway, and drilled and tapped to accept the impeller fastener. The impeller shaft extension shall conform to NEMA-JM specifications. The outboard shaft extension shall be machined with a keyway to accept a coupling to the driving unit. The shaft shall be steel AISI C1045.
- G. The pump shaft shall be fitted with a shaft sleeve to minimize shaft wear. The sleeve shall be sealed to the impeller hub by an O-ring, and shall be positively driven by a pin to the keyway. The shaft sleeve shall be Type 316 stainless steel.
- H. The power frame shall house a permanently lubricated single-row inboard ball bearing and permanently lubricated single-row outboard thrust bearing. Both bearings shall be selected for a 3-year minimum life at maximum load.
- I. The pump and motor shall be mounted on a groutable formed steel baseplate with integral drip channels incorporated on each side. Each channel shall include an NPT drain connection and plug.
- J. On full speed applications provide T.B. Woods flexible spaced coupling, equipped with coupling guards conforming to the requirements of ANSI B15.1. OSHA compliant coupling guards which fully enclose the coupling will be provided in lieu of standard steel shield. Variable speed applications must be supplied with a Dodge Paraflex coupler with a standard guard. Comply with pump and coupling manufacturers' written instructions. Final alignment

shall be made on-site, after the pump is installed and brought up to final operating temperatures. All flexibly coupled pumps must be aligned with a laser alignment system. Laser alignment reports for each pump must be turned over to the owner in the pump O&M package. The mechanical contractor is responsible for providing this service.

- K. Pumps shall be manufactured by Armstrong Pumps, Inc., Taco Pumps, Bell & Gossett Pumps, Weinman, Grundfos or Aurora.

## 2.3 TYPE "B" PUMP (CLOSE COUPLED INLINE FOR USE UP TO 5 HP)

- A. Pump shall be close coupled vertical or horizontal in-line type, single stage design. The pumps shall be capable of being serviced without disturbing piping connections.
- B. Cast iron, suitable for 175 psig working pressure at 140°F or ductile iron for pressures up to 250 psig. The casing shall incorporate a seal vent line to facilitate air removal and promote continuous water flush across the seal faces. The casing shall have tapped and plugged holes for priming, draining, and gauges.
- C. The impeller shall be of the enclosed type, vacuum cast in one piece and constructed of bronze, ASTM B584. The impeller shall be finished, the exterior being turned and the interior being finished smooth and cleaned. The impeller shall be dynamically balanced. The impeller shall be keyed to the shaft, fastened with a washer, gasket and capscrew.
- D. Shaft sealing shall be accomplished by means of a John Crane Mechanical seal suitable for 225°F operation. The seal shall have a ceramic seat, carbon washer, Buna-N elastomers, and stainless-steel metal parts.
- E. The pump shaft shall be ground and polished stainless-steel shaft with stainless steel sleeve.
- F. Pumps shall be manufactured by Armstrong Pumps, Inc., Taco Pumps, Bell & Gossett Pumps, Weinman, Grundfos, or Aurora.

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. Install all equipment in accordance with manufacturer's printed instructions and as indicated. Provide all required utilities, wiring, and accessories indicated or required. Properly test each piece of equipment to assure proper operation and demonstrate same to Owner's designated representative. Remove and replace at no expense to the Owner any item of equipment deemed by the Architect to be unsatisfactory.
- B. Provide start-up and adjustments for all systems and equipment in accordance with the manufacturer's recommendations using personnel who are factory trained and certified by factory as factory authorized personnel.

## HYDRONIC PUMPS



### 3.2 START-UP

- A. Provide start-up and adjustments for pumps in accordance with the manufacturer's recommendations using personnel who are factory trained and certified by the factory as factory authorized personnel.
- B. Verify that shipping, blocking, and bracing are removed.
- C. Verify that equipment is secure on mountings and supporting devices and that connections to piping and electrical systems are complete.
- D. Verify proper rotation and proper thermal-overload.
- E. Provide lubrication of all components with factory-recommended lubricants.
- F. Verify operating safeties are in place, piped or discharging to a safe location and functional prior to startup including but limited to the following:
  - 1. Electrical – Overloads installed, disconnects accessible, equipment covers and guards installed.
  - 2. Provide documentation of all pressure testing (piping and pressure vessels).
  - 3. Protect all equipment/systems operating during temporary or start-up operation. Provide startup filtration (water), strainers (water) to protect equipment.
  - 4. Check alignment of pump drives. Perform laser alignment of all flexibly coupled pumps. Submit final reports with O&M manuals.
  - 5. Retouch any marred or scratched factory-finished surfaces with materials furnished by the manufacturer.

END OF SECTION 23 21 23

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## SECTION 232500 – HVAC WATER TREATMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Section includes the following HVAC water-treatment systems:
  - 1. Closed hydronic water system(s) including chemistry, equipment and controls
  - 2. Monitoring and service of water treatment systems

#### 1.3 PERFORMANCE REQUIREMENTS

- A. Water quality for HVAC systems shall minimize corrosion, scale formation and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment. Owner shall retain/own all the feed and control equipment associated with the treatment program.
- B. Base water treatment product selections on the quality of makeup water available at project site taking into account the materials of construction for the HVAC systems and the performance requirements of this section.
- C. Closed hydronic systems, including hot-water, shall have the following water qualities unless aluminum materials of construction are present.
  - 1. pH: Maintain a value between 9.0 to 10.5.
  - 2. Soluble copper: Maintain a maximum value of 0.20 ppm.
  - 3. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
  - 4. Total Aerobic Plate Count: Maintain a maximum value of 1,000 CFU/ml or less.
- D. Passivation for galvanized steel: For the first 60-90 days of new equipment operation.
  - 1. Calcium: Maintain a minimum value of 50 ppm (as CaCO<sub>3</sub>) or more.
  - 2. "M" Alkalinity: Maintain a maximum value of 150 ppm or less.
  - 3. pH: Maintain a value between 7.0 to 8.0 to minimize the formation of white rust in combination with the passivation treatment chemistry. In no instance shall pH be permitted to fall below 6.5.

#### 1.4 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with Section 230050.
- B. Shop drawings: Pretreatment and chemical treatment equipment for all HVAC systems including the following:
  - 1. Provide layout and physical dimensions for all of the water treatment components to be installed in the mechanical room.
  - 2. If the treatment systems are to be installed outside of the mechanical room, include location, physical size and manufacturer of the supplemental weatherproof storage shed to be used.
  - 3. Include wiring diagrams for all field power and control wiring.
  - 4. Show all piping connections required to include inlet(s), outlet(s) and drain(s) along with associated connection size.
- C. Include plans, elevations, sections, details, and attachments to other work.
- D. Operation and maintenance manuals for controllers, chemical injection pumps, feeders, timers, valves, and system accessories.
- E. List of chemicals to be used for each system: Use generic names. Provide Safety Data Sheets (SDS) for each chemical used.
- F. Laboratory make-up water sample analyses: Submit a copy of the project site make-up water analysis to document the water quality available at the project site. Make-up water test analysis to include at a minimum the analysis of the following compositions of the water:
  - Calcium Hardness (as ppm  $\text{CaCO}_3$ )
  - Total Hardness (as ppm  $\text{CaCO}_3$ )
  - Total Alkalinity (as ppm  $\text{CaCO}_3$ )
  - pH
  - Silica (as  $\text{SiO}_2$ )
  - Specific Conductivity ( $\mu\text{S}/\text{cm}$ )
  - Sulfate (as  $\text{SO}_4$ )
  - Chloride (as  $\text{Cl}^-$ )
  - Phosphate (as  $\text{PO}_4$ )
- G. Provide a list of all services to be provided for all systems and the proposed procedure for system cleaning.

#### 1.5 QUALITY ASSURANCE

- A. The water treatment vendor shall be an experienced water treatment service provider capable of analyzing water qualities and applying water treatment as specified in this section. The vendor shall:

1. Obtain water samples from the site and furnish a laboratory analysis of the make-up water supply.
2. Review the make-up water analysis and materials of construction to ensure compatibility with the water treatment program and provide cycles of concentration calculations. See Schedule C.
3. Propose water treatment program required to maximize water efficiency based on Schedule C calculations; minimize material handling and storage while minimizing scale, corrosion and biological growth. Submit all of the above with shop drawings and other required submittals.
4. Chemicals selected shall comply with all the requirements of the American Public Health Association (APHA), the Environmental Protection Agency (EPA) and local environmental agencies.
5. Electrical components, devices, and accessories shall be listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

## PART 2 - PRODUCTS

### 2.1 WATER TREATMENT

- A. Complete chemical water treatment equipment and service shall be provided for the hydronic water systems by GBMC approved vendor. The treatment service shall provide all specified hardware, chemicals, and labor necessary for proper treatment for the specified warranty period for the following systems:

#### Hot Water Heating Systems

- B. The system shall provide service visits and reports, on a monthly basis as a minimum, for the purpose of monitoring performance, sampling and adjustments in treatment levels to achieve the desired results. At the end of the specified warranty period, the treatment company shall submit a detailed service report with complete records of previous adjustments and chemicals injected. Leave reports on site with the Owner after every service visit.
- C. The treatment company shall be responsible for damage to mechanical systems as a result of improper levels of treatment and/or damaging chemicals. The treatment company will not be responsible if the systems lose excessive amounts of water due to leakage.
- D. The water treatment contractor shall provide monthly reports after each required site visit. Reports shall be signed and received by the building's system operator.
- E. The water treatment contractor shall assist the mechanical contractor in the proper routing of piping and correct wiring requirements for the specific water treatment equipment installed.
- F. The water treatment program under this contract shall be provided for a period of one year from the date of system acceptance by the Owners' representatives. An initial dose of chemical shall also be applied immediately after each system is initially filled with water if operation is delayed after filling. The water treatment company shall provide chemical feeding

devices during the period of the contract. At the termination of the contract, the treatment equipment shall belong to the Owner.

## 2.2 CLOSED LOOP CHEMICAL FEED EQUIPMENT

- A. Bypass feeder shall have a minimum working pressure of 200 psi at 200 degrees F. Capacity shall be 5 gallons minimum. Feeder shall be furnished with inlet assembly and drain assembly, including isolation valves and fittings. Fill opening shall be 3 ½-inches. Feeder shall include a filter bag kit for side stream filter operation. (1) Box of 25 micron filter bags shall be provided with each bypass feeder.
- B. Corrosion Coupon Rack:
  - 1. Provide a three-station corrosion coupon rack constructed of Schedule 80 PVC, complete with piping, flow control valve and isolation valves. Entire assembly shall be mounted on a panel suitable for wall or rack mounting.
    - a. For hot water loops or closed systems operating above 120F carbon steel materials should be used in lieu of PVC.
  - 2. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
  - 3. Provide (1) mild steel and (1) copper coupon for initial 90 day analysis of each water system. Coupons shall be installed for at least 90 days and no longer than 120 days.
- C. Make-up Water Meter:
  - 1. Cold water, positive displacement, oscillating-piston, magnetic-drive, contacting totalizing meter.
  - 2. Must meet AWWA C700-15 standard.
  - 3. Minimum working-pressure rating: 30 psi.
  - 4. Maximum working-pressure rating: 150 psi.
  - 5. Registration: gallons, cubic feet, or liters/cubic meters.
  - 6. Controls (contact value or gallons per contact): Flow-control switch with normally open contacts must be rated for maximum 10A and 250 VAC and will close at the predetermined increment of flow.

## 2.3 CLOSED LOOP CHEMISTRY

- A. The mechanical contractor shall provide approved water treatment vendors with a calculated system volume for each closed loop to be treated at least 72 hours prior to the desired bid date and time. See Schedule A. Water treatment vendors will complete Schedule B and submit by bid due date.
- B. All chemicals shall be compatible with piping system components and all connected equipment and achieve water quality specified in Part 1 "Performance Requirements."
- C. Pre-cleaning chemistry: The cleaning solution shall be formulated to remove light grease, cutting oils, loose mill scale, organics and extraneous construction debris. No alkaline cleaners shall be allowed if any galvanized materials of construction are present. The cleaning program shall consist of the following:

1. Surfactant
  2. Polymeric dispersant
  3. Non-oxidizing biocide
  4. Antifoam, as required
- D. Hot Loop: A non-oxidizing biocide shall be slug fed semi-annually at a minimum to maintain good control of bacteria. Additional feed may be required if system exceeds listed Performance Requirements (section 1.3 C). The hot loop inhibitor shall be a multi-functional blend of nitrite, borate, azole and polymer. Dose and maintain the following targets for the hot loop system.
1. Nitrite 500 – 750ppm as NO<sub>2</sub>
- E. SDS sheets shall be provided on all chemical products. No systems shall be operated without the benefit of an operational chemical feed system.

## 2.4 CHEMICAL CONTAINMENT

- A. New containment systems are required for all liquid chemical products.
1. Containment system shall be fabricated from high-density opaque polyethylene or another material which is specifically selected as appropriate for the chemical to be contained.
  2. Minimum 110 percent containment capacity for each chemical to be contained.
  3. All liquid chemical inventories, whether opened or unopened, must be stored within containment systems suitable for each individual product.

## 2.5 CHEMICAL TREATMENT TEST EQUIPMENT

- A. Testing equipment: Test kits and test equipment shall be available for maintaining control of program standards in the HVAC water systems. Test kits will include the following:
1. Reagents and apparatus for determination of scale and corrosion inhibitor level in the HVAC water systems.
  2. Reagents and apparatus for determination of pH, alkalinity, free and total chlorine, and calcium hardness.
  3. Dip-slides for determination of microbiological colony population and biocide effectiveness.

## PART 3 - EXECUTION

### 3.1 WATER ANALYSIS

- A. Perform an analysis of supply makeup water to determine the type and quantities of chemical treatment needed to maintain the water quality as specified in "Performance Requirements".

### 3.2 INSTALLATION AND SERVICES

- A. Completely coordinate with work of all other trades.
- B. Install treatment equipment level and plumb and include all recommended clearances.
- C. Installation of water treatment equipment shall follow all recommendations from water treatment equipment vendor.
- D. Install water meter(s).
- E. Install corrosion coupon rack(s). Coupon rack(s) supply and return piping shall be piped using Schedule 80 PVC or carbon steel, copper is not allowed.
- F. The following services shall be supervised by the water treatment system vendor. Vendor shall coordinate installation with the mechanical contractor.
  - 1. Location and proper installation of liquid chemical containment.
  - 2. Location and proper installation, including mounting, of any controllers, chemical injection pumps, timers and valves.
  - 3. All piping and system components that are subject to freeze conditions shall have heat trace and insulation to protect the water treatment system from freezing.
  - 4. If the treatment system is to be installed outside of the mechanical room, a storage shed must be used which includes fans and or heaters to maintain the appropriate climate to prevent freezing and or excessive heat that could jeopardize the treatment chemicals or treatment system operation.
- G. Bypass Feeders: Mechanical contractor shall install a feeder in each closed hydronic system, including hot-water heating:
  - 1. Install the feeder in a bypass circuit across the recirculating pumps to provide sufficient differential pressure and adequate flow through the feeder, unless otherwise indicated on drawings.
  - 2. Bypass feeder shall be mounted such that the top of the feeder is no more than 4'0" above the finished floor.
  - 3. Install water meter in make-up water supply.
  - 4. Install corrosion coupon rack in bypass circuit around circulating pumps, unless otherwise indicated on drawings. Coupon rack supply and return piping shall be piped using Schedule 80 PVC or carbon steel, copper is not allowed.
  - 5. Pipe feeder drain to sanitary drain.
  - 6. Install isolation valves on inlet, outlet, and drain below feeder inlet.

### 3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Mechanical contractor shall install piping consistent with submittal drawings. Provide recommended access for service and maintenance.



### 3.4 FLUSHING AND CLEANING

- A. Pre-cleaning of closed loop systems: The water treatment supplier shall be responsible for supervising and furnishing the proper chemical for chemically cleaning all closed hydronic water systems. This cleaning program is not intended for potable water systems. The mechanical contractor shall provide labor for the pre-operational cleaning of all closed hydronic water systems including all piping and related equipment.
  - 1. The mechanical contractor shall flush all systems, including mud from drop legs. Remove, clean and replace all strainers.
  - 2. A minimum 1-1/2" ball or gate valve is to be permanently installed in the low point of each system for the purpose of draining each system.
  - 3. Complete circulation must be achieved during the cleaning procedure. A minimum flow rate of 3 ft/second needs to be maintained to ensure that the cleaning chemicals work properly. All manual, electrical, air and thermostatic operated valves must be open. All dead end runs must be looped together with piping not less than 1/3 the size of the run. This piping is to remain in place until cleaning is complete.

### 3.5 FIELD QUALITY CONTROL

- A. All services will be provided by a factory authorized service provider.
- B. The water treatment supplier shall inspect field-assembled components and equipment installation, including piping and electrical connections.
- C. The water treatment system supplier shall be on-site for start-up and commissioning including the following:
  - 1. Start and configure conductivity controller.
  - 2. Verify proper operation of motorized ball valve installed for bleed.
  - 3. Perform field tests on makeup water to verify that quality is consistent with laboratory analysis (Section 1.6 A. 1).
  - 4. Load, prime and start chemical inhibitor feed.
  - 5. Load, prime and start biocide feed.
- D. Provide water treatment services, for a period of 1-year from start-up of the system, which will include:
  - 1. Installation and system start-up procedure recommendations.
  - 2. Initial water analysis and recommendations.
  - 3. Training of operating personnel on proper feeding and control techniques.
  - 4. Monthly field service during periods of wet operation and provide written reports.
  - 5. Any necessary log sheets and record forms.

### 3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment. Refer to Section 01 79 00 "Demonstration and Training."

END OF SECTION 23 25 00

## SECTION 23 29 23 – VARIABLE FREQUENCY MOTOR CONTROLLERS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Section includes separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

#### 1.3 COMMISSIONING

- A. Division 23 will be responsible to carry out the commissioning requirements specified in Section 230010 and 230800.

#### 1.4 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with Section 230050:
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include plans, elevations, sections, and mounting or attachment details.
  - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field installation, and location and size of each field connection.
  - 4. Include diagrams for power, signal, and control wiring.
  - 5. Operation and maintenance manuals.

#### 1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.

## 1.6 WARRANTY

- A. General Warranty: Manufacturer's standard form in which manufacturer agrees to provide labor and materials to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period shall be 2 years from date of Substantial Completion not to exceed 30 months from date of shipment.

## PART 2 - PRODUCTS

### 2.1 VARIABLE TORQUE AC VARIABLE FREQUENCY CONTROLLER: PULSE WIDTH MODULATION TYPE

- A. AC Variable Frequency Controllers shall be provided as indicated on the plans. The variable frequency controller (VFC) shall convert three phase 60 Hertz utility power to adjustable voltage and frequency, three phase, AC power for stepless motor control from 10% to 110% of base speed.
- B. The VFC shall be a voltage source type with a PWM output utilizing IGBT transistor semi-conductors. The base VFC shall be UL Listed for 100 KAIC without the need for input fuses.
- C. The VFC shall meet EMI/RFI Product Standard EN61800-3 for First Environment Restricted Level.
- D. Seismic qualifications: By manufacturer, from qualified testing agency, shall comply with International Building Code.
- E. The VFC together with all options and modifications shall be mounted within a standard NEMA 12 enclosure suitable for continuous operation at an ambient temperature of 0° to 40° C with relative humidity to 95% non-condensing. All high voltage components within the enclosure shall be isolated with steel covers. The complete unit shall carry UL or ETL listing under standards UL508A and UL 61800-5-1; enclosures shall comply with NEMA 250.
- F. Circuits shall provide DV/DT and DI/DT protection for semi-conductors. VFC shall be capable of starting into a rotating load without delay. Protective circuits shall cause instantaneous trip (IET) should any of the following faults occur:
  - 1. 110% of controller maximum sine wave current rating is exceeded.
  - 2. Output phase to phase and phase to ground short circuit condition.
  - 3. High input line voltage.
  - 4. Low input line voltage.
  - 5. Loss of input phase.
  - 6. External fault. This protective circuit shall permit, by means of the terminal strip, wiring of remote NC safety contacts such as high static, firestat, etc., to de-energize the AFC.
- G. The following adjustments shall be available in the controller and retained in non-volatile memory:

1. Maximum frequency (15 to 500 hz) factory set at 60 hz.
2. Minimum frequency (3 to 60 hz) factory set at 6 hz.
3. Acceleration (.1 to 360 seconds) factory set at 20 seconds.
4. Deceleration (.1 to 360 seconds) factory set at 20 seconds.
5. Volts/Hertz ratio factory set for 460V at 60 hz.
6. Voltage offset or boost factory set at 100% torque.
7. Current limit (50% to 110% sine wave current rating) factory set at 100% current.

H. The VFC shall have the following basic features:

1. Door mounted operator controls consisting of membrane command center which will enable manual hand-off-auto and speed control, local/remote indication and manual/or automatic speed control selection. In addition, the command center will serve as a means to configure controller parameters such as minimum speed, maximum speed, acceleration and deceleration times, volts/hz ratio, and torque boost.
2. Main input disconnect to provide a possible disconnect of all phases of the incoming AC line to both the controller and the bypass circuitry. This disconnect shall be mounted inside the controller enclosure and have through-the-door interlocking toggle with provisions for padlocking.
3. Input fuses, or circuit breaker overcurrent protective device.
4. Electronic motor overload relay.
5. Automatic restart after power outage, drive fault or external fault, with drive in its automatic mode. The circuit shall enable the user to select up to five (5) restart attempts. The reset time between fault occurrences shall also be selectable. All settings shall be via the membrane command center.
6. Door-mounted LED display for digital indication of:
  - a. Frequency output.
  - b. Voltage output.
  - c. Current output.
  - d. First fault indication.
7. Relay for remote indication of drive fault and motor running.
8. Smoke purge circuit to enable acceptance from a contact closure from the building control and monitoring system (BCMS), that will start the controller regardless of mode and operate the motor at a preset adjustable speed.
9. A minimum of two critical frequency avoidance bands, field programmable via the membrane command center. Each critical frequency avoidance band shall have a bandwidth adjustable via the keypad of up to 10 Hz.
10. The drive shall be equipped with a direct interface device utilized to provide communication to the building BCMS system, Johnson Controls Inc, , and a USB port for communication with a PC.
11. Isolated process follower to enable VFC to follow a 4-20 MADC or 0-10VDC grounded or ungrounded signal.
12. The VFC shall have the capability to ride through power dips or outages up to 16.66 milliseconds without a controller trip.
13. AC line reactor 5% impedance to minimize line surges, line notching, and voltage distortions, or DC bus choke with 5% impedance (equivalent).

14. Manual bypass-to-line with magnetic contactors to transfer motor from the VFC to line speed operation on utility supplied input power while the motor is at any speed. Two motor contactors, electrically interlocked shall be utilized, one contactor between the controller output and the motor, and the other between the by pass power line and the motor, providing across the line starting.
  15. Motor protection per the NEC shall be provided in both the "controller" mode and the "bypass" mode by a motor overload relay. The 24 volt DC relay control logic, allowing common start/stop commands in the "controller" mode and the "bypass" mode shall also be included within the enclosure.
  16. In addition to the door interlocked, main power input disconnect providing positive shutdown of all power to both the bypass circuitry and the VFC. The bypass circuit shall provide a service switch to safely trouble shoot and test the controller, both energized and de-energized, while operating the bypass mode. Terminal connectors for over pressurization switches shall be provided, to protect the ductwork in the bypass mode.
  17. Control power transformer, 120VAC secondary, with primary and secondary fuses, sized to operate connected control burden plus 50VA.
- I. For single drive, multiple fan or pump operations, the VFC shall be provided with fuses and overload protection for each fan or pump separately. Termination points shall be provided for final wiring connections by Division 16. Provide means of disconnect for each pump or fan on enclosure.
  - J. Output Filtering: Provide DV/DT output filtering to limit standing waves as required for installed output circuit lead lengths, based on drive manufacturer's guidance.
  - K. The manufacturer shall have service and parts suppliers located within a two hour driving distance. Start-up service shall be provided by a factory authorized technician.
  - L. The VFC shall carry a full parts and labor warranty for two years from date of start-up.
  - M. Provide schematic single line diagrams of the VFC showing all power and control circuits as part of the shop drawing submittal.

## 2.2 MANUFACTURED UNITS

- A. Manufacturers: Subject to compliance with requirements, all drives shall be of one manufacturer. Third Party suppliers are not acceptable. Provide products by one of the following.
  1. ABB.
  2. Danfoss Inc.; Danfoss Drives Div.
  3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  4. Eaton
  5. Yaskawa
- B. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 61800-5-1.

- C. Application: Variable Torque
- D. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
  - 1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
  - 2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
  - 3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- E. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- F. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
- G. Unit Operating Requirements:
  - 1. Input AC Voltage Unbalance: Not exceeding 3 percent.
  - 2. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
  - 3. Minimum Efficiency: 98 percent at 60 Hz, full load.
  - 4. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
  - 5. Minimum Short-Circuit Current (Withstand) Rating: 65kA.
  - 6. Vibration Withstand: Comply with IEC 60068-2-6.
  - 7. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
  - 8. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
  - 9. Speed Regulation: Plus or minus 10 percent.
  - 10. Output Carrier Frequency: Selectable; 0.5 to 12 kHz.
  - 11. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- H. Inverter Logic: Microprocessor based, isolated from all power circuits.
- I. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
  - 1. Signal: Electrical.
- J. Internal Adjustability Capabilities:
  - 1. Minimum Speed: 5 to 25 percent of maximum rpm.

2. Maximum Speed: 80 to 100 percent of maximum rpm.
  3. Acceleration: .1 to 1800 seconds.
  4. Deceleration: .1 to 1800 seconds.
  5. Current Limit: 50 to minimum of 110 percent of maximum rating.
- K. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
  2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
  3. Under- and overvoltage trips.
  4. Inverter overcurrent trips.
  5. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
  6. Critical frequency rejection, with 3 selectable, adjustable deadbands.
  7. Instantaneous line-to-line and line-to-ground overcurrent trips.
  8. Loss-of-phase protection.
  9. Reverse-phase protection.
  10. Short-circuit protection.
  11. Motor overtemperature fault.
- L. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- P. Integral Input Disconnecting Means and OCPD: NEMA AB 1, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.
1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
  2. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.
  3. NC alarm contact that operates only when circuit breaker has tripped.



## 2.3 CONTROLS AND INDICATION

- A. Status Lights: Door-mounted LED indicators displaying the following conditions:
1. Power on.
  2. Run.
  3. Overvoltage.
  4. Line fault.
  5. Overcurrent.
  6. External fault.
- B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
  2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
    - a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
- C. Historical Logging Information and Displays:
1. Running log of total power versus time.
  2. Total run time.
  3. Fault log, maintaining last 3 faults with time and date stamp for each.
- D. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
1. Output frequency (Hz).
  2. Motor speed (rpm).
  3. Motor status (running, stop, fault).
  4. Motor current (amperes).
  5. Motor torque (percent).
  6. Fault or alarming status (code).
  7. PID feedback signal (percent).
  8. DC-link voltage (V dc).
  9. Set point frequency (Hz).
  10. Motor output voltage (V ac).
- E. Control Signal Interfaces:
1. Electric Input Signal Interface:

- a. A minimum of two programmable analog inputs: 0- to 10-V dc and 4- to 20-mA dc.
    - b. A minimum of six multifunction programmable digital inputs.
  2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
    - a. 0- to 10-V dc.
    - b. 4- to 20-mA dc.
    - c. Potentiometer using up/down digital inputs.
    - d. Fixed frequencies using digital inputs.
  3. Output Signal Interface: A minimum of 2 programmable analog output signal(s) (0- to 10-V dc and 4- to 20-mA dc) which can be configured for any of the following:
    - a. Output frequency (Hz).
    - b. Output current (load).
    - c. DC-link voltage (V dc).
    - d. Motor torque (percent).
    - e. Motor speed (rpm).
    - f. Set point frequency (Hz).
  4. Remote Indication Interface: A minimum of 2 programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
    - a. Motor running.
    - b. Set point speed reached.
    - c. Fault and warning indication (overtemperature or overcurrent).
    - d. PID high- or low-speed limits reached.
- F. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms and energy usage. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory. The VFC shall have an RS-485 port as standard.
1. Network Communications Ports: Ethernet and RS-485
- G. Embedded BAS Protocols for Network Communications: The standard protocols shall be Modbus, BACnet, Johnson Controls N2 bus, and Siemens Building Technologies FLN. Each individual drive shall have the protocol in the base VFC.

## 2.4 LINE CONDITIONING AND FILTERING

- A. Input Line Conditioning: Passive harmonic filter, selected to limit input Voltage and Current Total Harmonic Distortion (THD%) to IEEE 519 (2014 Revision) Table 2 limits when the point of common coupling is defined as the input terminals to the VFC. Filter shall also provide minimum 5% reactive line impedance. Filter package shall be MTE Matrix AP or equal and shall be incorporated into the bypass cabinet or supplied in a separate NEMA 3R enclosure.

- B. Output Filtering: For distances between VFC and Motor over 50 feet, and as indicated on the Drawings, provide dV/dT output filter.
- C. EMI/RFI Filtering: CE Mark – The VFC shall conform to the European Union ElectroMagnetic Compatibility directive, a requirement for CE marking.

## 2.5 BYPASS SYSTEMS

- A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter. The Bypass system must be able to detect a single phase input power condition while running in bypass. The system (VFC and Bypass) tolerated voltage window shall allow the system to operate from a line of +30%, -35% nominal voltage. The Bypass system shall NOT depend on the VFC for bypass operation.
- B. Bypass Controller: Shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label. The bypass enclosure door and VFC enclosure must be interlocked such that input power is turned off before either enclosure can be opened. The VFC and Bypass as a package shall have a UL listed short circuit rating of 65,000 RMS Symmetrical Amperes, as determined by UL 508A Supplement SB method or by testing methods approved and verified by the listing agency. Short circuit rating shall be indicated on the data label.
  - 1. A complete factory wired and tested bypass system consisting of an output contactor and bypass contactor, service (isolation) switch and VFC input fuses are required
  - 2. Door interlocked, padlockable circuit breaker that will disconnect all input power from the drive and all internally mounted options.
  - 3. The bypass controller shall have six (6) programmable digital inputs, and five programmable Form C relay outputs.
- C. Bypass Contactor Configuration: Full-voltage (across-the-line)
  - 1. Bypass Hand-Off-Auto
  - 2. NORMAL/BYPASS selector switch Bypass Hand-Off-Auto
  - 3. Drive mode selector and light
  - 4. Bypass mode selector and light
  - 5. Bypass fault reset
  - 6. Bypass LDC display, 2 lines, for programming and status / fault / warning indications.
  - 7. Overload Relays: Class 10, 20, or 30 (selectable) electronic motor overload protection shall be included.

## 2.6 ADDITIONAL FEATURES

- A. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.
  - 1. Firefighter's Override (Smoke Purge) Input: Upon receipt of a contact closure from the fireman's control station, the VFC shall operate in one of two modes: 1) Operate at a

programmed predetermined fixed speed or operate in a specific fireman's override PID algorithm that automatically adjusts motor speed based on override setpoint and feedback. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands), except customer defined safety run interlock, and force the motor to run in one of the two modes above. "Override Mode" shall be displayed on the keypad. Upon removal of the override signal, the VFC shall resume normal operation.

- B. Communication Port: RS-485, RS-232 port, USB 2.0 port, or equivalent connection.

## 2.7 ENCLOSURES

- A. VFC Enclosures: The VFC package as specified herein shall be enclosed in a UL Listed Type enclosure, (NEMA rated enclosures are not acceptable) completely assembled and tested by the manufacturer in an ISO9001 facility to comply with environmental conditions at installed location.

- 1. Dry and Clean Indoor Locations: Enclosure shall be rated UL type 12.

## 2.8 ACCESSORIES

- A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

- 1. All VFCs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFCs.
  - 2. The keypad shall include Hand-Off-Auto selections and manual speed control. There shall be fault reset and "Help" buttons on the keypad. The Help button shall include "on-line" assistance for programming and troubleshooting.
  - 3. There shall be a built-in time clock in the VFC keypad. The clock shall have a battery back up with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault.

- B. Reversible NC/NO bypass contactor auxiliary contact(s).

- C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

- D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

- 1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

## 2.9 SOURCE QUALITY CONTROL

- A. Testing: VFC package as specified herein shall be enclosed in a UL Listed Type enclosure, (NEMA rated enclosures are not acceptable) completely assembled and tested by the manufacturer in an ISO9001 facility.
  - 1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
  - 2. Verification of Performance: Rate VFCs according to operation of functions and features specified.
- B. VFCs will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Wall-Mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks.
- C. Install fuses in each fusible-switch VFC.
- D. Install fuses in control circuits if not factory installed.
- E. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- F. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- G. Comply with NECA 1.

### 3.2 IDENTIFICATION

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified.
  - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - 2. Label each VFC with engraved nameplate.
  - 3. Label each enclosure-mounted control and pilot device.

### 3.3 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Division 26.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic control devices where applicable.
  - 1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
  - 2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Acceptance Testing Preparation:
  - 1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- C. Tests and Inspections:
  - 1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
  - 2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
  - 3. Test continuity of each circuit.
  - 4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
  - 5. Test each motor for proper phase rotation.
  - 6. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  - 7. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

### 3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.

### 3.6 ADJUSTING

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.
- D. Set the taps on reduced-voltage autotransformer controllers.
- E. Set field-adjustable circuit-breaker trip ranges.
- F. Set field-adjustable pressure switches.

### 3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

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## SECTION 23 33 00 - DUCTWORK AND ACCESSORIES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections apply to this section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. This section includes the air distribution system including those devices distributing the air to the spaces, and those items which collect, filter, control, and convey air.
- B. Except for duct pressure tests, all testing and balancing of the air distribution system shall be performed under Section 23 05 93 of the Specifications.

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with Section 23 00 50.
  - 1. Include construction details, materials description, dimensions of individual components and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include mounting or attachment details.
  - 3. Include details of equipment assemblies. Indicate dimensions, weight, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams for power, signal, and control wiring.

### PART 2 - PRODUCTS

#### 2.1 AIR DEVICES

- A. Provide air devices of minimum sizes and quantities indicated and of the types specified. Contractor shall carefully study the drawings and the field conditions to ascertain the air device requirements as to suitability, location, air capacity, required accessories and finish. Devices shall be selected to provide draft-free air distribution over entire area served and sound rating shall not exceed scheduled NC level. Shop drawings shall indicate NC values.
- B. Provide Titus, Krueger, Nailor, Anemostat, or Price air devices in accordance with the schedule.

- C. Size of grilles and registers indicated on the drawings for installation in acoustical tile grid systems are nominal size. Devices shall be selected to fit standard ceiling tile space within the suspended grid.
- D. Margins and frames shall be as indicated or directed to suit field conditions. Devices shall have plaster frames when installed in plaster or drywall construction.
- E. Finishes shall be as specified herein. Devices installed in acoustical tile ceilings shall be white baked enamel finish.
- F. Finish (off-white) of T-bar diffusers shall match specified ceiling grid system. Perimeter T-bars adjacent to Type "A" diffusers shall be provided by the ceiling contractor. All center T-bars shall be supplied with air device.
- G. All devices located in toilet rooms, locker areas, and kitchens shall be of aluminum construction, unless otherwise specified herein.
- H. Paint ductwork behind grilles and registers with flat black enamel so that bright surface of metal cannot be seen. Properly prime galvanized surface prior to painting.
- I. For air devices furnished with internally lined plenums, provide 1 1/2 lb. density closed cell foam fiber free type.
- J. Provide air devices in accordance with the air device schedule on the drawings.

## 2.2 FIRE DAMPERS

- A. Fire dampers shall be Ruskin, Air Balance, National Controlled Air, Greenheck, Pottorff, United Enertech or approved equal U.L. labeled dynamic dampers. Damper shall match the wall, floor or ceiling rating in which it is installed, except no damper shall have less than 1-1/2 hour rating. Dampers shall be all welded construction and shall be fitted with integral galvanized sleeves. Dampers shall be Type "B" for low pressure rectangular ducts and Type "C" for circular, flat oval, or rectangular as required for medium pressure ducts. Dampers behind grilles and registers shall be Type "A".
- B. Fire damper assembly shall include fire damper and damper enclosure wall sleeve complete with duct attachment flanges, in accordance with all code requirements. Provide an access door (minimum 12" x 12") at each fire damper located so as to permit easy maintenance of damper and fusible link. Provide 165°F fusible link. All fire dampers shall be installed in accordance with NFPA requirements.
- C. Submit shop drawings indicating installation details, samples upon request, and manufacturer's installation drawings for approval to the Architect of all fire damper assemblies for low pressure and medium pressure duct systems. Dampers shall not be installed prior to receiving written approval of submitted samples.

## 2.3 COMBINATION FIRE SMOKE DAMPERS

- A. Combination fire smoke dampers shall be 1-1/2 hour rated under UL Standard 555, and shall further be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. The leakage rating under UL555S for medium pressure duct applications shall be no higher than leakage class I (4 cfm/SF at 1" w.g. and 8 cfm/SF at 4" w.g.). The leakage rating under UL555S for low pressure duct applications shall be no higher than leakage class II (10 cfm/SF at 1" w.g.). Elevated temperature rating shall be 250° F.
- B. Include on submittal data information for evaluation of damper flow characteristics, certified leakage rates and electrical load information (current at specified voltage).
- C. Damper frames shall be constructed of minimum 16 gage galvanized steel channel. Blades for medium pressure duct applications shall be airfoil shaped double skin construction. Blade edge seals shall be silicone rubber designed for smoke seal to 450°F. Jamb seal shall be flexible metal compression type. Bearings shall be stainless steel sleeves, pressed into frame. Damper materials shall be consistent with requirements of installed duct systems. Damper sleeve gage shall be in accordance with UL555 and NFPA 90A.
- D. Actuators shall be installed by the damper manufacturer at time of damper fabrication. Actuator shall be normally closed 120-volt AC two position type. Damper and actuator shall be supplied as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and actuators. Qualified actuators (supplied by damper manufacturer or ATC contractor) shipped loose for field mounting, must bear a U.L. label affixed by the damper manufacturer.
- E. Provide damper test switch and two position blade indicator switch. Provide factory mounted end switch Ruskin Model SP-100 for all dampers.
- F. Combination fire smoke dampers shall be equipped with a fusible link which shall melt at 165°F causing damper to close and lock in a closed position.
- G. Combination fire smoke dampers for medium pressure duct applications shall be Ruskin Model FSD-60 or approved equal by Greenheck, Air Balance, NCA, Pottorff or United Enertech. Combination fire smoke dampers for low pressure duct applications shall be Ruskin Model FSD-36 or approved equal.

## 2.4 SMOKE DAMPERS

- A. Smoke dampers shall be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. The leakage rating under UL555S for medium pressure duct applications shall be no higher than leakage class I (4 cfm/SF at 1" w.g. and 8 cfm/SF at 4" w.g. The leakage rating under UL555S for low pressure duct applications shall be no higher than leakage class II (10 cfm/SF at 1" w.g.). Elevated temperature rating shall be 250°F.
- B. Include on submittal data information for evaluation of damper flow characteristics, certified leakage rates and electrical load information (current at specified voltage).

- C. Damper frames shall be constructed of minimum 16 gage galvanized steel channel. Blades for medium pressure duct applications shall be airfoil shaped double skin construction. Blade edge seals shall be silicone rubber designed for smoke seal to 450°F. Jamb seal shall be flexible metal compression type. Bearings shall be stainless steel sleeves, pressed into frame. Damper materials shall be consistent with requirements of installed duct systems. Damper sleeve gage shall be in accordance with UL555 and NFPA 90A.
- D. Actuators shall be installed by the damper manufacturer at time of damper fabrication. Actuator shall be normally closed 120 volt AC two position type. Damper and actuator shall be supplied as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and actuators. Qualified actuators (supplied by damper manufacturer or ATC contractor) shipped loose for field mounting, must bear a U.L. label affixed by the damper manufacturer.
- E. Provide damper test switch and two position blade indicator switch. Provide factory mounted end switch Ruskin Model SP-100 for all dampers.
- F. Smoke dampers for medium pressure duct applications shall be Ruskin Model SD-60 or approved equal by Greenheck, Air Balance, NCA, Pottorff or United Enertech. Smoke dampers for low pressure duct applications shall be Ruskin Model SD-36 or approved equal.
- G. Smoke isolation dampers at unit discharge shall be Ruskin Model SD-102, UL555S, Class 2 or approved equal.
- H. Smoke isolation dampers for unit inlet locations shall be Ruskin Model SD-60 or approved equal.

## 2.5 DUCTWORK

- A. General
  - 1. The Duct Manual as herein referenced shall mean the SMACNA manual as published by the Sheet Metal and Air Conditioning Contractors National Association, Inc.
  - 2. Unless noted otherwise, ductwork shall be constructed of prime, first quality galvanized steel of gauges as called for in the Duct Manual. Reinforce all ducts to prevent buckling, breathing, vibrations, or unnecessary noise. Such reinforcing shall be as recommended in Duct Manual, plus any additional reinforcing as required to meet job conditions. Longitudinal and cross joints, elbows, transitions, etc, shall be furnished as specified in Duct Manual, including recommended duct supports to suit job conditions.
  - 3. All uninsulated rectangular ductwork shall be crossbroken on all four sides of each panel section. All vertical and horizontal sheet metal barriers, duct offsets and elbows, as well as the panels of straight sections of ducts, shall be crossbroken. Crossbreaking shall be applied between the standing seams or reinforcing angles. The center of the crossbreak shall be of the required height to assure each panel section being rigid, to prevent vibrations and "breathing."
  - 4. Prior to fabrication of any ductwork, Contractor shall submit to the Architect for approval shop drawings and data for each duct system which shall describe for each duct, the size, gauge, material, joint type, seam type, and reinforcement to be provided.

All construction shall be in accordance with the requirements hereinafter specified. No ductwork shall be fabricated or installed until the details of construction are submitted and approved. Ductwork installed at variance to these conditions shall be subject to removal and replacement at no cost to the Owner.

5. Provide 22-gauge galvanized sleeve around ducts passing through drywall construction.
6. Provide 22-gauge aluminum flanged trim collar and sleeve around exposed ducts through walls, floor or ceilings in finished areas to provide finished appearance.

B. Low Pressure Ductwork-Less Than 2" Pressure Class

1. Ductwork shall conform with requirements and details, unless specified or indicated otherwise in the Duct Manual, "HVAC Duct Construction Standards, Metal and Flexible," 2005 with all addenda. A copy of the Duct Manual shall be secured by the Contractor and shall be kept at the project for convenient reference.
2. Flexible duct connections at air handling unit connections, where indicated or required to eliminate duct vibration shall be "Ventglass" duct fabric as manufactured by Ventfabrics, Inc., or approved equal.
3. Except as noted herein under "Medium Pressure Ductwork," all ductwork including supply air, outside air, return air, and exhaust air provided on the project shall be low pressure construction. Rectangular low-pressure ductwork construction shall conform to the following SMACNA Standards:

- |  |   |
|--|---|
| 1. Material gauges                               | Refer to the "Duct Construction Schedule" on the drawings.                  |
| 2. Longitudinal Seams                            | Fig. 2-2, Types L-1, L-2 & L-4  |
| 3. Corner Closures                               | Fig. 2-14, 2-15, 2-17 & 2-18  |
| 4. Hangers                                       | Fig. 5-1, 5-2, & 5-5 & Tables 5-1 & 5-2                                     |
| 5. Rectangular Elbows                            | Fig. 4-2, Types RE-1 & RE-2   |
| 6. Vaned Elbows (Applies to RE-2 type)           | Fig. 4-3 & 4-4, Runner Type 1 to have a vane at each tab                    |
| 7. Offsets & Transitions                         | Fig. 4-7  |
| 8. Branch Connections                            | Fig. 4-6, 45° or conical only   |
| 9. Volume dampers (up to and including 12" deep) | Fig. 7-4, Figs. A&B w/locking quadrant                                      |
| 10. Volume dampers (over 12" deep)               | Fig. 7-5 w/locking quadrant   |
| 11. Access doors                                 | Minimum 12"x12" unless otherwise noted. Provide cam lock latches, insulated |

4. Duct sizes indicated on the drawings are air side sizes.
5. Seal all traverse joints and fittings in all low-pressure supply, return, and exhaust ductwork and reheat coil connections to supply air terminal units with United Duct Sealer. At contractor's option, mineral impregnated woven fiber tape as manufactured by Hardcast, Inc. shall be considered equal.
6. Provide Elgen Model E115, E116, or E117 low leakage or approved equal quadrant on all volume dampers.
7. Provide stand-offs, on volume dampers installed in all insulated ductwork. Depths of stand-offs shall exceed thickness of specified insulation to provide sufficient operating clearances.
8. Flexible ductwork shall be Hart & Cooley Type F-116 or approved equal. Flexible duct shall comply with NFPA Bulletin 90A and shall be U.L. listed as Class 1 Air Duct & Connector, Standard 181. Flexible duct shall be approved and suitable for installation in ceiling return air plenums.
9. Provide Conical Fittings with integral volume damper, at flexible duct connections to sheet metal duct. Seal all fittings to sheet metal duct with United Duct Sealer.
10. Support all ducts in accordance with Duct Manual, Tables 5-1 & 5-2 and as hereinbefore specified and as indicated and noted on the drawings.

C. Medium and High Pressure Ductwork-Greater Than 2" Pressure Class

1. Medium and high pressure ductwork shall be rated as indicated on the "Duct Construction Schedule" on the drawings.
2. Medium and high pressure ductwork shall consist of rectangular and circular types as indicated on the drawings. At contractor's option, rectangular ductwork may be substituted for circular type. Equivalent circular sizes to rectangular sizes shall be maintained. Submit rectangular duct sizes for approval.
3. Ductwork, other than medium or high pressure type specified herein, including supply, return, relief, outdoor air, and exhaust shall be low pressure ductwork.
4. All medium and high pressure duct systems shall be leak tested in strict conformance with SMACNA standards. Tests shall be witnessed by the balance subcontractor as hereinafter specified.
5. Rectangular medium or high pressure ductwork, unless otherwise specified herein, shall conform with the requirements and details contained in the Duct Manual, "HVAC Duct Construction Standards, Metal and Flexible," 2005 with all addenda hereinafter referred to as "Duct Manual." A copy of the Duct Manual shall be secured by the Contractor and shall be kept at the project for convenient reference. Construction shall conform to the following:

- |                           |  |
|---------------------------|--|
| 1. Reinforcement & Gauges | Refer to the "Duct Construction Schedule" on the drawings. |
| 2. Traverse Joints        | Table 2-32, Figs. T-22, 2-2, T-24 & T-24a                  |
| 3. Longitudinal Joints    | Figs. #2-2, L-1 and L-3                                    |

- |     |                        |   |
|-----|------------------------|---|
| 4.  | Vanes and Vane Runners | Fig. #4-3 & 4-4 Runner Type-1 to have a vane at each tab                        |
| 5.  | Branch Connections     | Fig. #4-6 45° only  |
| 6.  | Offsets & Transitions  | Fig. #4-7   |
| 7.  | Supporting Systems     | Fig. #5-5 Trapeze type only, Tables 5-1 & 5-2                                   |
| 8.  | Riser Supports         | Fig. #5-8 Fig B   |
| 9.  | Volume Dampers         | Ruskin CD-60 Airfoil  |
| 10. | Duct Sealants          | See Pages 1-11 through 1-13. Use 3M EC-750 or approved equal, on seams & joints |
| 11. | Access Doors           | Ruskin or approved equal minimum 12" x 12", with cam lock latches, insulated    |
| 12. | Welded galvanized      | Coated with minimum two coats of corrosion resistant aluminum paint             |

D. Circular Medium Pressure Ductwork:

1. Circular medium pressure ductwork shall be manufactured by McGill AirFlow, Semco, Lindab Safe, Sheet Metal Connectors, Inc., TNT Manufacturing, Inc., MKT Metals, or Eastern Sheet Metal and shall consist of spiral pipe and welded fittings that shall be factory painted. Circular duct shall have locked seams so made as to eliminate any leakage under the pressures for which the system has been designed. Longitudinal seam duct shall have fusion welded butt seam. All welded seams shall be factory painted. Circular duct shall be manufactured of galvanized steel meeting ASTM A-527-80 by the spiral lockseam method and in the minimum gauges listed:
  - a. For systems operating at 2.0" W.G. or less positive pressure the minimum gauges shall be as follows:

<u>Diameter</u>	<u>Spiral Seam</u>	<u>Longitudinal</u>
<u>Seam</u>		
- 8"	28	26
- 14"	28	26
- 26"	26	24
- 36"	24	22

- 50"                      22                                      20

- b. For systems operating at up to 10.0" W.G. or less positive pressure the minimum gauges shall be as follows:

<u>Diameter Seam</u>	<u>Spiral Seam</u>	<u>Longitudinal</u>
- 8"	26	24
- 14"	26	24
- 26"	24	22
- 36"	22	20
- 50"	20	20

- c. For systems operating between 0.0" and 2.0" W.G. negative the minimum gauges shall be as follows:

<u>Diameter Seam</u>	<u>Spiral Seam</u>	<u>Longitudinal</u>
- 8"	28	24
- 14"	26	24
- 26"	24	22
- 36"	22	20
- 50"	20	18

2. All fittings are to have continuous welds along all seams. All welded seams shall be factory painted. All divided flow fittings are to be manufactured as separate fittings, not as tap collars welded into spiral duct sections. Fittings and couplings shall be of the following minimum gauges:

<u>Diameter</u>	<u>Minimum Gauge</u>
Through 14"	24
Through 26"	22
Through 50"	20

3. All 90 degree tees and 45 degree laterals, either full size or reducing shall be conical pattern produced by machine or press forming. The entrance shall be free of weld build-up, burrs, or irregularities. Provide tangential tees where indicated and as required to suit the installation.
4. Elbow diameters 3" through 8" shall be two section die-stamped elbows. All other elbows shall be gored construction with all seams continuous-welded and painted. Elbows shall be fabricated in a centerline radius of 1.5 times the cross section diameter. All elbows not die-stamped shall be fabricated according to the following schedule:



<u>Elbow Angle</u>	<u>No. of Gores</u>
Less than 30°	2
30° through 60°	3
Over 60°	5

5. The reduction of divided flow fittings shall be conical spun section in the thirty-six reductions in sizes 4" through 22".
6. Offset fitting shall be constructed so that length is not less than 2 duct diameters.
7. Galvanized areas that have been damaged by welding shall be coated with corrosion resistant aluminum paint, minimum 2 coats.
8. Supports, sealants and testing shall conform with applicable portions of the Duct Manual and as hereinbefore specified.
9. Flexible ductwork in medium pressure duct systems shall be Hart & Cooley Genflex Type SLR-25VM or approved equal.
10. Dampers in circular M.P. duct systems shall be Ruskin Model CDR 92 or approved equal with locking type quadrant.
11. Seal all transverse joints, longitudinal seams and duct wall penetrations in medium and high pressure ductwork in accordance with duct sealing requirements of the "Duct Construction Manual".

## 2.6 AIR MEASURING DEVICES

- A. Provide air measuring stations and transmitters in the ductwork of the sizes and capacities indicated on the drawings. Refer to automatic temperature control diagrams and contract drawings for size and type.
- B. Devices shall be as manufactured by Ebtron Gold Series or Tek-Air compatible with the variable air volume (VAV) system sequences, or as indicated on the contract documents, or approved equal. Flow station transmitters shall be field selectable, fuse protected and isolated 0-10 VDC and 4-20 MA (4 wire) signal. System accuracy shall be within 3% of reading.
- C. Ebtron sensor housings shall be mounted in an extruded, gold anodized, 6063 aluminum tube probe assembly.
- D. Each station shall be installed with minimum upstream and downstream clearances in accordance with the manufacturer's printed instruction.
- E. Air measuring devices installed at fan inlets shall be equal to Ebtron GTX116F.
- F. Transmitters shall be microprocessor based with LED display, or approved equal.

## 2.7 AIR MEASURING DEVICES: VORTEX SHEDDING TYPE

- A. Provide air measuring stations and transmitter in the ductwork of the sizes and capacities indicated on the drawings. Refer to automatic temperature controls diagrams and contract drawings for size and type.

- B. Devices shall be as manufactured by Tek-Air Systems, Inc. equal to Model Vortek VT-5000 for duct areas above four (4) square feet and Model Vortek VT-2000 for duct areas four (4) square feet and below, compatible with the variable air volume (VAV) system sequences as specified in Section 23 09 00, or as indicated on the contract documents, or equal.
- C. Airflow measuring devices of the Vortex Shedding type, capable of continuously monitoring the airflow volume of the duct served and electronically transmitting a signal linear to the airflow volume, shall be provided where indicated. Airflow measuring devices shall be of the insertion type, as required, with the capability of measuring velocity sensors, supported on insertion probe bars.
- D. Individual airflow sensors shall be of rugged construction and shall not require special handling during installation. Sensors shall be mounted on support bars, as required to achieve an equal area traverse. Standard Materials shall be aluminum bars with aluminum and ABS sensors. Support bars over one foot in length shall be supported on both ends. Where utilized in corrosive air streams, sensors and support bars shall be manufactured of corrosion resistant CPVC and ABS. All mounting hardware required shall be furnished by the Laboratory Airflow Control System Manufacturer.
- E. Individual velocity sensors shall not be affected by dust, temperature, pressure, or humidity. The sensors shall be passive in nature, with no active parts within the air stream. The output from individual sensors shall be linear with respect to airflow velocity and shall be capable of sensing airflow in one direction only. The velocity sensors shall not require calibration.
- F. Multiple sensors shall be utilized in ducts as required.
- G. Velocity measurements from individual sensors shall be summed in the integrally connected airflow transmitter. The measurement shall be input and conditioned digitally to eliminate Analog-to-Digital conversion input error. The transmitter shall provide a scalable output over the full range of control of the unit, via on-board adjustments. The output signal of the transmitter shall be industry standard electronic signals, selectable on-board via jumpers or switches, for 4-20ma, 1-5vdc or 2-10vdc. Power requirement for the transmitter shall be 24VAC or DC.
- H. Transmitter Requirements: Calibrated spans: 0 to 896 fpm up to 5664 fpm, in eight flow range increments.
- I. Transmitter Performance Characteristics:
  - 1. Reference accuracy (include non-linearity, hysteresis, and non-repeatability): +/- 1% full scale.
  - 2. Output signal: 4 - 20mA or 2-10 VDC
  - 3. Temperature Effects: +/- .033% full scale/°F between 40°F to 100°F range. Original calibration at 70°F.
  - 4. Power Supply: 24 VDC unregulated.
  - 5. The transmitter shall not be damaged by over-pressurization up to 200 times greater than span, shall be furnished with a factory calibrated span. The transmitter shall be

housed in a stainless-steel case with external signal tubing, power and output signal connections.

- J. Vortex shedding type air measuring devices shall be provided in all exhaust and return systems as indicated in contract drawings.

## 2.8 LOUVERS

- A. Louvers shall be provided under the architectural division. Mechanical contractor shall confirm louvers include wire birdscreen, 50% free area, and water penetration of 0.01 ounces per SF of free area at a louver free area velocity of no less than 1000 fpm.

## 2.9 AUTOMATIC CONTROL DAMPERS

- A. Dampers shall be factory fabricated and shall have flow control characteristics required by each individual application. For modulating dampers under actual operating conditions, provide type which produces a linear relationship between air flow and operating range.
- B. Include on submittal data information which will establish suitability of dampers proposed (sizes and types), show inherent flow characteristics of the various types of dampers (individual and combination) for each application required for the project. Also furnish certified data on damper leakage rate and operator power criteria.
- C. Dampers, when closed, shall not leak in excess of 3 cfm per square foot at 1-inch water gage static pressure differential and be so certified by the manufacturer Class 1A. Furnish damper operators having sufficient power to limit leakage to the rate specified.
- D. Dampers shall be extruded aluminum or galvanized, low leakage, with airfoil blades. Frames shall be 5" x 1" x 1/8" extruded aluminum or aluminum hat channel with hat mounting flanges on both sides of the frame. Each corner shall be reinforced with two die-formed internal braces. Blade edge seals shall be extruded vinyl double edge design and shall be locked in extruded blade slots without use of cement. Bearings shall be non-corrosive two piece molded synthetic. Axles shall be square or hexagonal to provide positive connection to blades and linkages.
- E. All dampers shall have neoprene damper seals at all blade edges and ends suitable for an operating range down to 0°F at the lower end and 200°F at the upper end.
- F. Where rectangular dampers are twelve (12) inches or more in a direction perpendicular to the axis, use sectionalized type with blade width not exceeding eight (8) inches. Where rectangular damper is larger than four (4) square feet in area, use corner braces. Blade length is not to exceed forty-eight (48) inches.
- G. Operating link, i.e. connection rods transmitting motion from damper motors to damper, shall be sized to withstand a load equal to at least twice the maximum damper operating force without deflection. Make lengths adjustable and construct of brass, bronze or steel. For zinc-coated or cadmium plated steel links, construct working part of joints, e.g. clevises, and ball-and-socket joints of bronze or stainless steel.

- H. Provide for adjustment for blade travel in either direction. Control the open and closed position of pneumatic operated dampers by controlling the stroke of motor by adjustment stops or by adjustment of crank arm.
- I. Factory finish parts of steel damper with two coats of rust inhibitive paint.
- J. Dampers shall be Ruskin or approved equal by TAMCO Series 1500, or Pottorff Model CD, scheduled as follows:
  - 1. Control dampers shall be galvanized steel construction - CD 60 or aluminum construction - CD-40.
  - 2. Isolation dampers (high pressure fan discharge application) shall be galvanized construction - CD-80 AF-1 or aluminum construction CD/OD 102.
  - 3. Shutoff dampers for outdoor air intake and exhaust openings shall be Class 1 and have leakage rate no greater than 4 cfm per square foot at 1.0 inch water gauge and labeled in accordance with AMCA 500D.

### PART 3 - EXECUTION

#### 3.1 AIR DEVICES

- A. Install air devices in accordance with the manufacturer's latest published installation instructions to insure against incorrect air pattern, drafts, and dirt smudging.
- B. Construct, and install sheet metal duct or plenum connections to air devices in accordance with manufacturer's recommendations.
- C. Make modifications of duct systems required to accommodate actual sizes of air devices furnished, e.g. transformations and collar sizes, without additional cost.

#### 3.2 FIRE DAMPERS, SMOKE DAMPERS, AND COMBINATION FIRE/SMOKE DAMPERS

- A. All fire dampers, smoke dampers, and combination fire/smoke dampers shall be tested upon installation, and at a period of one year after project completion. Contractor shall inspect, test and provide a written report documenting the testing procedure prior to the expiration date of the one-year warranty. Any dampers failing inspection shall be repaired/replaced at no additional cost to the owner.
- B. The dampers shall be tested in accordance with NFPA 80 and 105, and Joint Commission Standard EC.02.03.05 EP18. Per NFPA 80, dampers shall be tested and operation documented after installation. Each damper must be numbered and tested. The installing or testing contractor shall request a test sheet with available device numbers from the Facilities Department. Each electrical or pneumatic device shall be operated locally and through the fire alarm system and closure verified. The printed report from the fire alarm system shall be provided to indicate the operation of the initiating device. Each gravity fire alarm system shall be provided to indicate the operation of the initiating device. Each gravity fire link shall be released and damper closure verified. The device shall be logged on the test sheet with the initials of the tester, type of device, location, and date of test. All testing shall be in the presence of a witness from the Facilities Department and the commissioning agent.

### 3.3 DUCTWORK

- A. Install hangers, supports, and their attachments, generally, in conformance with SMACNA standards referred to in this section of the specifications.
- B. Furnish hangers capable of withstanding 5 times the weight of the load imposed on them without Damage to duct or any adjacent construction.
- C. Neatly erect ducts and plenums of sizes and arrangements shown and detailed and as required to carry out intent of specifications and drawings. Work must meet approval of the Architect in all its parts and details.
- D. Sizes shown are air side sizes. Where ducts are indicated as lined, dimensions shall be increased to reflect the thickness of the lining.
- E. Install ductwork in such a manner as to meet recommendations of NFPA Standard 90A.
- F. Contractor shall review and coordinate the installation of the ductwork. No ductwork shall be fabricated prior to the contractor obtaining exact field dimensions of the building structure, including new and existing ceiling space conditions, architectural, mechanical, electrical, and structural obstructions, etc, which may affect the installation of the air distribution system. Notify the Architect immediately upon any discrepancies.
- G. Because of the small scale of the drawings, it is not possible to indicate all duct offsets, rises, drops, fittings and accessories which may be required. Carefully investigate in the field the architectural, mechanical, electrical, and structural conditions affecting the work, and arrange such work accordingly, providing such fittings, and accessories as may be required to meet such conditions.
- H. Provide each air outlet with a collar adequately stiffened, fastened, and made suitable for securing air device thereto. Make field changes in ductwork, such as those required to accommodate the sizes of factory fabricated equipment actually furnished, i.e., VAV terminal units, coils, fans, filter housings, and similar items, without additional cost. Provide duct flanges to match those of connecting factory fabricated equipment. When necessary, relocate and modify ductwork to avoid obstructions such as structural members, piping and conduit, in a manner acceptable to the Architect.
- I. Construct and install all ductwork in accordance with the SMACNA Standard specified.
- J. Leak Testing of Ductwork:
  - 1. Low Pressure System: Test all low-pressure ductwork (pressure class less than 2" w.g.), scheduled for Seal Class A or B. Leakage testing shall be performed on 25% of the installed low pressure ductwork. Random testing of low-pressure ductwork, downstream of all terminal units shall be required if duct sealing appears inadequate. Testing methodology shall be in accordance with SMACNA's "HVAC Air Duct Leakage Test Manual". Refer to the duct construction schedule on the drawings for additional information.

Allowable Leakage shall be determined by the following formula:

$$F = C_L \times P^{0.65}$$

F =	Leakage (CFM/100 ft <sup>2</sup> of duct surface)
C <sub>L</sub> =	12 (rectangular ductwork)
C <sub>L</sub> =	6 (round ductwork)
C <sub>L</sub> =	4 (all ductwork located outdoors)
P =	Duct Leakage Test Pressure (in. w.g.)

Keep ducts free of audible leaks which are detectable in all finished spaces. Notify testing and balancing contractor who shall witness tests, at least 48 hours in advance of tests.

2. Medium Pressure System: Test all ductwork with a pressure class of 2" w.g. or greater. Leakage testing shall be performed on 100% of the installed ductwork. Testing methodology shall be in accordance with SMACNA's "HVAC Air Duct Leakage Test Manual." Refer to the duct construction schedule on the drawings for additional information.

Allowable Leakage shall be determined by the following formula:

$$F = C_L \times P^{0.65}$$

F =	Leakage (CFM/100 ft <sup>2</sup> of duct surface)
C <sub>L</sub> =	12 (rectangular ductwork)
C <sub>L</sub> =	6 (round ductwork)
C <sub>L</sub> =	4 (all ductwork located outdoors)
P =	Duct Leakage Test Pressure (in. w.g.)

Keep ducts free of audible leaks which are detectable in all finished spaces. Notify testing and balancing contractor who shall witness tests, at least 48 hours in advance of tests.

K. Cleaning:

1. Clean the inside of ductwork and casing of debris, dirt, and other foreign matter before any system's fans and filters are operated for any reason. After the equipment has been used temporarily for any purpose, i.e., adjusting, testing and ventilating, clean or renew (depending on type) filter media and clean ducts downstream from the filters which have handled unfiltered air. Additionally, clean exhaust and return ducts, which in the opinion of the Architect, have been handling excessive dirty air prior to acceptance of the system.
2. Keep main duct risers capped with plastic or poly after duct testing to help maintain clean risers. Provide roll filter media at each open-end duct to help maintain clean risers until project balancing begins.

END OF SECTION 23 33 00

## SECTION 23 34 00 - FANS AND VENTILATORS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 of specifications sections, apply this section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. This section includes:
  - 1. Fans

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with section 23 00 50.
  - 1. Include construction details, material descriptions, dimensions of individual components, and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include plans, elevations, sections, and mounting or attachment details.
  - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams for power, signal, and control wiring.
  - 5. Operation and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 GENERAL

- A. Provide fans having a certified rating based on tests performed in accordance with AMCA Bulletins Number 210, 211A and 300. See AMCA Standard 99 "Standard Handbook" for definitions of fan terminology. Arrangement, size and capacity of fans are indicated on the drawings.

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- B. All fans shall be statically and dynamically balanced by the manufacturer. Field mounted vibration isolation units as hereinbefore specified shall be installed on each fan.
- C. Diffuser cones and inlet bells are not permitted in rating a fan unless they are an integral part of the fan design. Additionally, where applicable, fans shall not be rated for air-over (AO) duty.
- D. Provide inlets and outlets of fans not duct connected, including fans in plenum chambers or open to outside, with heavy guard screens to protect personnel. Construct guard screens in a manner that will not impair fan performance, and when bolted to equipment will permit their removal for fan service and cleaning.
- E. Provide lubrication facilities, such as oil reservoirs, sight glasses, grease and relief fittings, fill and drain plugs, pipe connections, etc. Place in a readily and safely accessible location so that after installation they will perform required function without requiring the dismantling of any parts or stopping equipment.
- F. All parts of fans shall be protected against corrosion prior to operation of the fan.
- G. Certified performance data including acoustical data shall be submitted for each fan at design conditions. Data shall include published sound power levels based on actual test on the fan sizes being furnished, and conducted in accordance with current, AMCA Standards. Such data shall define Sound Power Levels (PWL), re: 10-12 watts for each of the eight frequency bands. Sound Power Levels shall not exceed those scheduled. Should additional attenuation be required to achieve the levels specified, it shall be included by the fan manufacturer. Any cost of field modifications necessitated by additional attenuation shall be so included by the fan manufacturer. Fan curves shall be submitted which will depict static pressure, total pressure, brake horsepower, and mechanical efficiency plotted against air volume. Data submitted in tabular form is not acceptable.
- H. Motors, drives, curbs, and bases shall be furnished by the fan manufacturer in accordance with the requirements of Section 23 00 10. Note potential drive change requirements for motors 20 HP and above.

## 2.2 Utility Centrifugal Fans (Type D)

- A. The fans shall be of the single width, single inlet design with forward or backward inclined or airfoil blades as manufactured by Twin City, Loren Cook, Greenheck, or Penn Barry. Fans shall be belt driven in arrangement 10, and of minimum AMCA Class I construction, or Class II if indicated on the plans. The housing shall be constructed of steel with all seams continuously welded. Sizes up to 330 shall be of the rotatable design, convertible to eight standard discharge configurations.
- B. Shafts shall be AISI C-1040 or C-1045 hot rolled and accurately turned, polished, and ring gauged for accuracy. Close tolerances are to be maintained where the shaft makes contact with the bearings. All shafts shall be dial indicated for straightness after the keyways are cut. Shaft diameters shall have first critical speed of at least 1.25.

## FANS AND VENTILATORS



- C. All fans are to have heavy duty bearings, grease lubricated, precision anti-friction ball, self aligning pillow block type. Bearings shall be selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150% of driven horsepower. Sheaves and motors shall be in accordance with Section 23 00 10.
- D. Each fan component shall be thoroughly degreased and deburred before the application of a rust preventative primer. After complete assembly, a second coat of primer shall be applied to the complete assembly. Where scheduled, fans shall be provided with corrosion resistant special coatings on all surfaces exposed to the airstream.
- E. All fan ratings shall be based on tests made in accordance with AMCA Standard 210-85 and all fans shall be licensed to bear the AMCA Certified Ratings seal for air and sound. Each fan shall be run fully assembled at the factory at maximum class RPM. The total fan assembly shall be checked for balance and checked against the acceptable levels on the Rathbone chart.
- F. All fans shall be furnished with scroll access doors, drain fittings and belt guards per OSHA requirements. Fans located outdoors shall be equipped with weather enclosure.
- G. Domed Exhaust Ventilators (Type "H")
  - 1. Domed centrifugal power roof ventilators shall be Acme Engineering Inc., Loren Cook, or JENco, equal to Greenheck Model GB or G as scheduled.
  - 2. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. The fan shroud shall have a rolled bead for added strength.
  - 3. Fan wheels shall be of the centrifugal backward curved non-overloading design, direct or V-belt drive as scheduled. Fan wheel and fan housing shall be of heavy gauge all aluminum construction, with motor and drive assembly located out of exhaust airstream in separate compartment that is forced air cooled with outside air. All exposed fasteners shall be stainless steel.
  - 4. Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearing shall be selected for a minimum of (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150% of driven horsepower.
  - 5. Motors shall be in accordance with Section 23 00 10 of these Specifications. Single-phase direct drive fans, unless for explosion proof application, shall have solid-state speed controller, factory mounted in motor compartment and factory wired to fan motor.
  - 6. All fans shall be provided with birdscreen, factory-wired safety switch and motorized backdraft damper. Prefabricated roof curbs shall be fully welded galvanized steel, 12" high, with insulation, wood nailer, and cant. For pitched roofs, curbs shall be constructed to match roof pitch.

## 2.3 Direct Driven Propeller Fans (Type "J")

- A. Direct drive propeller fans shall be Greenheck Model SE, as scheduled on plans, or equal by Loren Cook, Acme, or Breidert.

## FANS AND VENTILATORS

- B. Fans shall be direct drive with non-overloading aluminum or steel propeller, heavy gauge steel panel, TEFC motor, and motor side fan guard. Single phase motors shall have integral thermal overload protection and shall be permanently lubricated. Motors shall be in accordance with Section 23 00 10.
- C. All steel parts shall be phosphatized and painted with epoxy primer and corrosion resistant polyester coating.
- D. Fans shall carry the AMCA Certified Rating Seal for Air and Sound. Supply fans shall be of reverse-flow configuration. Provide Motor-Operated backdraft damper and screen guard for each fan.
- E. Inline Centrifugal Cabinet Fan: (Type "L")
  - 1. Inline centrifugal cabinet fans shall be Greenheck Model SQ, as scheduled on plans, or equal by Twin City, Loren Cook, Acme or JENco.
  - 2. The fan housing shall be of the square design with square duct mounting collars.
  - 3. The fan wheel shall be centrifugal backward inclined, constructed of aluminum, V-belt drive or direct drive. Fan wheel and fan housing shall be of heavy gauge construction, with motor located out of exhaust airstream.
  - 4. Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for minimum of 150% of driven horsepower.
  - 5. Motors shall be in accordance with Section 230010 of these Specifications. Single phase direct drive fans, unless for explosion proof application, shall have solid state speed controller, factory mounted in motor compartment and factory wired to fan motor.
  - 6. All fans shall carry AMCA Certified Rating Seal for Air and Sound performance. All fans shall be provided with birdscreen and motorized backdraft damper.

#### 2.4 Vertical Centrifugal Exhaust Fan (Type "M")

- A. Vertical inline centrifugal type fans shall be Greenheck Vektor H, Penn Barry Model FH, Cook Model TCNGBLE, or approved equal by Strobic Air, or Twin City.
- B. The fan housing shall be of all welded carbon steel construction, epoxy coated, with the bearing assembly contained in a completely welded tapered tube. The housing shall be equipped with flow conversion vanes to efficiently convert the flow from the wheel to an axial direction. The housing shall be equipped with a threaded drain connection.
- C. The fan shall be belt drive as indicated on the schedule and shall incorporate a 7' discharge stack with construction matching that of the fan. The fan shall be capable of supporting additional stack sections up to 20' in height if the stack is properly guy wired.
- D. The fan wheel shall be non-overloading backward inclined. Wheels shall be statically and dynamically balanced. A gasketed access door shall be provided for access to the wheel.

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- E. The fan shall be equipped with cast iron, self-aligning pillow block bearings. Lubrication lines shall be extended to the outside of the fan. The fans shall be provided with a Teflon shaft seal. Shafts shall be fabricated of polished steel.
- F. Provide a weather cover to protect the motor and drive assembly. The cover shall be removable for access to the motors and drive. Belts shall be capable of replacement from the exterior of the fan.
- G. The fans shall be provided with an all welded steel curb cap, hot dipped galvanized after fabrication. The curb shall be equipped with a wiring post to facilitate running of conduit to the motor. The curb cap shall be built with a slip-fit duct connection collar.
- H. The fans shall be provided with a galvanized prefab roof curb, sized to match the fan. The curbs shall be minimum 12 inches high, single or double pitched to match the specific application.
- I. The fans shall be equipped with a discharge cap with a deep spun steel discharge venturi sized to control the discharge velocity as required by the application with minimum pressure loss.
- J. The fans shall be factory painted with industrial grade enamel or epoxy paint.
- K. Provide an inlet mixed air plenum constructed of fully welded steel. The plenum shall be factory painted with a baked enamel or epoxy finish. For special coatings refer to fan schedule. The plenum shall be single wall construction. The plenum shall include a bolted access door for inspection. Bleed dampers shall be airfoil type, opposed blade as specified within this section of the specification. The damper section shall be protected by a rainhood with birdscreen. Isolation damper shall be an opposed blade airfoil type as specified within this section of the specification. Operators shall be furnished and installed by the project control contractor. The mixed plenum shall be manufactured by the fan supplier and shall be constructed to fully support the fans and accessories. The plenum shall be rigid without vibration and breathing.
- L. Fan performance rating shall be based on methods and standards as developed by AMCA in Standard 210. The minimum outlet velocity shall not be below 3000 fpm per ANSI-Z95. The fan's tested and rated inlet volume as based on AMCA's established test methods shall be the volume used to determine the outlet velocity of the fan.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install fans level and plumb.
- B. Install fans with clearances for service and maintenance.

### FANS AND VENTILATORS

### 3.2 FIELD QUALITY CONTROL

- A. Provide start-up and adjustments for lab/isolation type exhaust fans in accordance with the manufacturer's recommendations using personnel who are factory trained and certified by the factory as factory authorized personnel.
- B. Test and inspect components, assemblies, and equipment installations, including connections.
- C. Verify that shipping, blocking, and bracing are removed.
- D. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
- E. Verify that cleaning and adjusting are complete.
- F. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
- G. Adjust belt tension.
- H. Adjust damper linkages for proper damper operation.
- I. Verify lubrication for bearings and other moving parts.
- J. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
- K. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
- L. Shut unit down and reconnect automatic temperature-control operators.
- M. Remove and replace malfunctioning units and retest as specified above.
- N. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.
- O. Adjust damper linkages for proper damper operation.
- P. Adjust belt tension.
- Q. Lubricate bearings.

END OF SECTION 23 34 00

## SECTION 23 36 00 - AIR TERMINAL UNITS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Section includes specifications for the following equipment:

- 1. Air Terminal Units

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with section 23 00 50.
  - 1. Include construction details, material descriptions, dimensions of individual components and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
  - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, methods of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams of power, signal and control wiring.
  - 5. Operation and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 VARIABLE AIR VOLUME CONTROL UNITS

- A. Provide low pressure variable air volume control units as indicated on the plans.
- B. Type "SDV" Unit (Digital)
  - 1. Units shall be Titus, Enviro Tec, Johnson Controls, Krueger, Nailor, Trane, or Price, equal to Price Model SDV, suitable for single duct variable air volume installation. Capacities shall be as scheduled on the drawings.
  - 2. The unit casing shall be minimum 22 gauge galvanized steel with a steel bladed damper. All seams shall be factory sealed to prevent leakage.
  - 3. The terminals shall have an approved non-porous EPFI sealed liner. The liner and insulation must meet the requirements of U.L. 181 and NFPA 90A. The liner must meet

bacteriological standards of ASTM C665. Liners made of Tedlar, Mylar, Silane or Alpha-Temp are not acceptable. Insulation shall be 1.5 pound density, 3/8 inch thick with a thermal conductivity of 0.25 BTU-in/hr-ft<sup>2</sup>. The lining shall be the Price FF sealed Fiber Free lining system or approved equal.

4. The unit inlet shall be equipped with a cross-shaped flow sensor with amplifying pick-up points connected to central averaging chambers. The sensor shall maintain control accuracy with the inlet duct in any configuration. All pneumatic tubing shall be UL listed, fire retardant (FR) type.
5. Sound ratings shall be tested as power levels to 10<sup>-12</sup> watts and shall not exceed values scheduled. The manufacturer shall furnish certified sound power levels for both discharge sound and casing radiated sound, tested in accordance with ASHRAE Standard 37-72. Sound data based on prior ASHRAE Standards will not be acceptable. The tests shall be conducted in an ARI-ADC approved sound facility. The data shall include the second through sixth octave bands for all unit sizes with multiple inlet static pressures. All attenuation factors shall be clearly defined. Provide additional approved attenuation as required to achieve the scheduled values. Sound power levels shall be submitted for each unit at its scheduled maximum air volume and inlet pressure of 1" w.g.
6. The direct digital controls (DDC) shall be provided by the automatic temperature control contractor. Controller shall be shipped to terminal unit manufacturer for factory mounting. The terminal unit manufacturer shall mount the electronic damper actuator and velocity flow sensor. Refer to Section 23 09 00 for additional requirements. The damper actuator shall apply at least 40 in-lbs of torque to the damper shaft. Electronic actuators shall be provided by the automatic temperature control contractor.
7. Hot water coil shall be provided with unit where scheduled. Coil shall be constructed of aluminum fins mechanically bonded to copper tubes. Coils shall be designed for minimum working pressure of 150 psig and shall be air tested under water at minimum 250 psig. Coil capacity shall be as scheduled and shall be ARI certified. At the contractor's option, an extended hot water coil section with a minimum 5"x5" access door with cam lock fasteners may be provided in lieu of a contractor provided access door.

C. Type "SRDV": (Return/Exhaust Terminals)(Digital)

1. Units shall be Titus, Enviro Tec, Johnson Controls, Krueger, or Price, equal to Price Model SRDV. Capacities shall be as scheduled on the drawings.
2. The unit casing shall be minimum 22 gauge galvanized steel with a steel bladed damper. All seams shall be factory sealed to prevent leakage.
3. The unit inlet shall be furnished with a cross-shaped flow sensor with amplifying pick-up points connected to central averaging chambers. The sensor shall maintain control accuracy with the inlet duct in any configuration. All pneumatic tubing shall be UL listed, fire retardant (FR) type.
4. Sound ratings shall be tested as power levels to 10-12 watts and shall not exceed values scheduled. The manufacturer shall furnish certified sound power levels for both discharge sound and casing radiated sound, tested in accordance with ASHRAE Standard 37-72. Sound data based on prior ASHRAE Standards will not be acceptable. The tests shall be conducted in an ARI-ADC approved sound facility. The data shall include the second through sixth octave bands for all unit sizes with multiple inlet static pressures. All attenuation factors shall be clearly defined. Provide additional approved attenuation

as required to achieve the scheduled values. Sound power levels shall be submitted for each unit at its scheduled maximum air volume and inlet pressure of 1" w.g.

5. The direct digital controls (DDC) shall be provided by the automatic temperature control contractor. Controller shall be shipped to terminal unit manufacturer for factory mounting. The terminal unit manufacturer shall mount the electronic damper actuator and velocity flow sensor. Refer to Section 23 09 00 for additional requirements. The damper actuator shall apply at least 40 in-lbs of torque to the damper shaft. Electronic actuators shall be provided by the automatic temperature control contractor.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

##### A. VAV Terminal Units

1. Install terminal units in accordance with details shown on the drawings. Provide all necessary supports as indicated and required. Locate units to provide full accessibility to all damper operators, controllers and accessories.

#### 3.2 START-UP

- A. Start-up shall include verifying proper installation, testing all valves & set points
- B. TAB (Test and Balance) contractor shall be responsible for final verification of airflow measurement.

END OF SECTION 23 36 00

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## SECTION 23 52 16 – HIGH MASS CONDENSING BOILERS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, pulse-combustion condensing boilers, trim, and accessories for generating hot water.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Wiring Diagrams: Power, signal, and control wiring.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Source quality-control test reports.
- B. Field quality-control test reports.
- C. Warranty: Special warranty specified in this Section.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

#### 1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
- C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- D. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

## 1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

## 1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Pulse-Combustion Boilers:
    - a. Complete Heat Exchanger Assembly: 10 years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 CONDENSING HOT WATER BOILER (NATURAL GAS)

- A. Manufacturers: Subject to compliance with requirements, provide Fulton Endura Condensing Hydronic Boiler, or approved equal by Aerco, Patterson Kelly, or RBI.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
  - 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical spaces for suitable conditions where boilers will be installed.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 BOILER INSTALLATION

- A. Equipment Mounting: Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases specified in Section 03 30 00 "Cast-in-Place Concrete."
  - 1. Coordinate sizes and locations of concrete bases with actual equipment provided.
  - 2. Construct bases to withstand, without damage to equipment, seismic force required by code.
  - 3. Construct concrete bases 4 inches high and extend base not less than 6 inches in all directions beyond the maximum dimensions of boiler unless otherwise indicated or unless required for seismic anchor support.
  - 4. Minimum Compressive Strength: 5000 PSI at 28 days.
  - 5. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
  - 6. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
  - 7. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 8. Install anchor bolts to elevations required for proper attachment to supported equipment.

### 3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to boiler to allow service and maintenance.
- C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
- D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service.
- E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

- F. Connect hot-water piping to supply- and return-boiler tapings with shutoff valve and union or flange at each connection.
- G. Install piping from safety relief valves to nearest floor drain.
- H. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- I. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

### 3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
  - 1. Perform installation and startup checks according to manufacturer's written instructions.
  - 2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
  - 3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
    - b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

### 3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Video training sessions. Refer to Section 01 79 00 "Demonstration and Training."

END OF SECTION 23 52 16

## SECTION 23 74 13 – ROOFTOP MODULAR AIR HANDLING UNITS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. This Section includes packaged, outdoor, modular air-handling units (rooftop units) with the following components and accessories:
  - 1. Economizer outdoor- and return-air damper section.

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this Section in accordance with Section 23 00 50.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the product.
  - 2. Include rate capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include plans, elevations, sections, and mounting or attachment details.
  - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams for power, signal and control wiring.
  - 5. Operation and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 MODULAR ROOFTOP AIR HANDLING UNITS

- A. Furnish and install as indicated on the contract drawing modular rooftop units as manufactured by Trane, Carrier, or Daikin.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
- B. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
  - 1. Install ducts to termination at top of roof curb.
  - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
  - 3. Connect supply ducts to RTUs with flexible duct connectors.
  - 4. Install return-air duct continuously through roof structure.

### 3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
  - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
  - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

### 3.3 STARTUP SERVICE

- A. Complete installation and startup checks according to manufacturer's written instructions and do the following:
  - 1. Inspect for visible damage to unit casing.
  - 2. Inspect for visible damage to coils and fans.
  - 3. Inspect internal insulation.
  - 4. Verify that labels are clearly visible.
  - 5. Verify that clearances have been provided for servicing.
  - 6. Verify that controls are connected and operable.
  - 7. Verify that filters are installed.
  - 8. Remove packing from vibration isolators.
  - 9. Inspect operation of barometric relief dampers.
  - 10. Verify lubrication on fan and motor bearings.
  - 11. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
  - 12. Adjust fan belts to proper alignment and tension.
  - 13. Start unit according to manufacturer's written instructions.
  - 14. Inspect and record performance of interlocks and protective devices; verify sequences.
  - 15. Operate unit for an initial period as recommended or required by manufacturer.

16. Calibrate thermostats.
17. Adjust and inspect high-temperature limits.
18. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
19. Inspect controls for correct sequencing of heating, mixing dampers, cooling, and normal and emergency shutdown.
20. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
  - a. Supply-air volume.
  - b. Return-air volume.
  - c. Relief-air volume.
  - d. Outdoor-air intake volume.
21. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

#### 3.4 CLEANING AND ADJUSTING

- A. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

END OF SECTION 237413



## SECTION 23 74 16 – PACKAGED ROOFTOP UNITS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Section includes the design, controls and installation requirements for packaged rooftop units / outdoor air handling units.

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with Section 23 00 50:
  - 1. Include rated capacities, operating characteristics, fan performance curves, filter information, electrical characteristics, and furnished specialties and accessories. Include plans, sections, and mounting or attachment details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field installation, and location and size of each field connection.
  - 3. Include diagrams for power, signal, and control wiring.
  - 4. Operation and maintenance manuals.

#### 1.4 QUALITY ASSURANCE

- A. Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.
- B. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.
- C. Unit Energy Efficiency Ratio (EER) shall be equal to or greater that prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.
- D. Unit shall be safety certified by ETL and ETL US listed. Unit nameplate shall include the ETL/ETL Canada label.

## 1.5 WARRANTY

- A. Manufacturer shall provide a limited “parts only” warranty for a period of 60 months from the date of original equipment shipment from the factory. Warranty shall cover material and workmanship that prove defective, within the specified warranty period. Warranty excludes parts associated with routine maintenance, such as belts and filters.

## PART 2 - PRODUCTS

### 2.1 PACKAGED ROOFTOP UNITS

- A. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, air-cooled condenser coils, condenser fans, hot water coil, and unit controls. Units shall be as manufactured by Trane, Carrier, (JCI) York, Daikin, Aeon or approved equal.
- B. Unit shall be factory assembled and tested including leak testing of the DX coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the service compartment's literature pocket.
  - 1. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
  - 2. Unit components shall be labeled, including refrigeration system components and electrical and controls components.
  - 3. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's hinged access door.
- C. Construction
  - 1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
  - 2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.
  - 3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, prevents heat transfer through the panel, and prevents exterior condensation on the panel.
  - 4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.
  - 5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.

6. Access to filters, dampers, cooling coils, reheat coil, heaters, exhaust fans, compressors, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles.
7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.
9. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.
10. Unit shall include lifting lugs on the top of the unit.
11. Unit base pan shall be provided with 1/2 inch thick foam insulation.

D. Electrical

1. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.
2. Air-source heat pump shall include an optimized start defrost cycle to prevent frost accumulation on the outdoor coil during heat pump heating operation and to minimized defrost cycle energy usage. If the temperature of the outdoor heat exchanger and/or the suction line is less than a predetermined value, a deferred defrost cycle is initiated wherein the defrost cycle starts after a variable, continuously optimizing, time interval has elapsed. The defrost cycle is terminated when the relative temperatures of the outdoor heat exchanger and/or the suction line indicate that sufficient frost is melted from the heat exchanger to insure adequate time between successive defrost cycles for optimizing the efficiency and reliability of the system, or after a predetermined time interval has elapsed, whichever condition occurs first. During defrost cycle all compressors shall energize, reversing valves shall de-energize, and auxiliary heat shall energize.
3. Unit shall be provided with a factory installed and factory wired 115V, 13 amp GFI outlet disconnect switch in the unit control panel.
4. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on voltage, the voltage is more than 10% under design voltage or on phase reversal.

E. Supply Fans

1. Unit shall include direct drive, unhooded, backward curved, plenum supply fans.
2. Blowers and motors shall be dynamically balance and mounted on rubber isolators.
3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
4. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

F. Cooling Coils

1. Evaporator Coils
  - a. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.
  - b. Coils shall have interlaced circuitry and shall be standard capacity.

- c. Coils shall be hydrogen or helium leak tested.
- d. Coils shall be furnished with factory installed expansion valves.

G. Refrigeration System

- 1. Unit shall be factory charged with R-410A refrigerant.
- 2. Compressors shall be scroll type with thermal overload protection and carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory.
- 3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam injected panels to prevent the transmission of noise outside the cabinet.
- 4. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.
- 5. Each refrigeration circuit shall be equipped with expansion valve type refrigerant flow control.
- 6. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides and a factory installed replaceable core liquid line filter driers.
- 7. Unit shall include a variable capacity scroll compressor on all refrigeration circuits which shall be capable of modulation from 10-100% of its capacity.
- 8. Lead refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.
- 9. Unit shall be configured as an air-source heat pump. Each refrigeration circuit shall be equipped with a factory installed liquid line filter drier with check valve, reversing valve, accumulator, and expansion valves on both the indoor and outdoor coils. Reversing valve shall energize during the heat pump cooling mode of operation.
- 10. Each refrigeration circuit shall include adjustable compressor lockouts.

H. Condensers

- 1. Condenser fans shall be a vertical discharge, axial flow, direct drive fans.
- 2. Heat pump outdoor coil shall be constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
- 3. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.
- 4. Coils shall be hydrogen or helium leak tested.
- 5. Condenser fans shall be VFD driven variable speed for condenser head pressure control. Factory provided and factory programmed VFDs shall continuously modulate the fan air flow to maintain head pressure at acceptable levels. Cooling operation shall be allowed down to 35°F with adjustable compressor lockouts.

I. Hot Water Heating Coils

- 1. Hot water reheat coils shall be provided where scheduled. Coils shall be constructed of aluminum fins mechanically bonded to copper tubes. Coils shall be designed for

minimum working pressure of 150 psig and shall be air tested under water at minimum 250 psig. Coil capacity shall be as scheduled and shall be ARI certified.

J. Filters

1. Unit shall include 4 inch thick, pleated panel filters with a MERV rating of 13, upstream of the cooling coil. Unit shall also include 2 inch thick, pleated panel pre filters with an ASHRAE efficiency of 30% and MERV rating of 8, upstream of the 4 inch standard filters.

K. Outdoor Air

1. Unit shall include 100% motor operated outside air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge and end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly shall be controlled by spring return, 2 position actuator. Unit shall include outside air opening bird screen and outside air hood.

L. Controls

1. Factory Installed and Factory Provided Controller
  - a. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested. Controller shall be capable of stand alone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.
  - b. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.
  - c. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
  - d. Constant Volume Controller
    - 1) Unit shall modulate cooling with constant airflow to meet space temperature cooling loads.
    - 2) With modulating hot gas reheat, unit shall modulate cooling and hot gas reheat as efficiently as possible, to meet space humidity loads and prevent supply air temperature swings and overcooling of the space.
    - 3) Unit shall modulate heating with constant airflow to meet space temperature heating loads. Modulating heating capacity shall modulate based on supply air temperature.
  - e. Unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad, interface module with touch screen, or with connection to PC with free configuration software. Controller shall be capable of connection with other factory installed and factory provided unit controllers with individual unit configuration, setpoint adjustment, sensor status viewing, and occupancy scheduling available from a single unit. Connection between unit controllers shall be with a modular cable. Controller shall be capable of communicating and integrating with a LonWorks or BACnet network.

M. Accessories

1. Unit shall be provided with a safety shutdown terminal block for field installation of a smoke detector which shuts off the unit's control circuit.
2. Provide manufacturer's standard roof curb.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install unit, including field installed components, in accordance with manufacturers Installation, Operation, and Maintenance manual instructions.

3.2 START-UP

- A. Start up and maintenance requirements shall be complied with to ensure safe and correct operation of the unit.
- B. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.

3.3 ADJUSTING

- A. Adjust moving parts to function smoothly, and lubricate as recommended by manufacturer.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 23 74 16

## SECTION 23 81 00 - PACKAGED AND SPLIT-SYSTEM AIR-CONDITIONING UNITS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with Section 23 00 50:
  - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include mounting or attachment details, and finishes.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include diagrams for power, signal, and control wiring.
  - 4. Operation and maintenance manuals.

#### 1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

### PART 2 - PRODUCTS

#### 2.1 DUCTLESS SPLIT-SYSTEM A/C AND HEAT PUMP UNIT

- A. The system shall consist of a slim, silhouette, compact wall mounted evaporator unit with wireless controller and a horizontal discharge, single phase outdoor unit. The system shall be Mitsubishi Mr. Slim P-Series or equal. Unit performance shall be based on 80°F DB, 67°F WB for the indoor unit and 95°F DB, 75°F WB for the outdoor unit.

- B. The unit shall be listed by Electrical Laboratories (ETL) and shall bear ETL label. All wiring shall be in accordance with the National Electric Code (NEC). The units shall be rate on accordance with ARI Standard 210.
- C. The indoor unit shall be factory assembled, wired and run tested. The unit cabinet shall contain all factory wiring, piping, control circuit board and fan motor. The unit cabinet shall have a white finish with a separate back plate that secures the unit to the wall.
- D. The evaporator fan shall be an assembly with a direct drive fan with a single motor. The fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings.
- E. The unit shall be provided with a removable, washable filter.
- F. The evaporator coil shall be of nonferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tubing joints shall be brazed with phoscopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.
- G. The outdoor unit shall be designed specifically for use with the indoor unit. The unit shall be factory assembled, piped and wired. The casing shall be fabricated of galvanized steel, bonderized and finished with a powder coated baked enamel. The unit shall be provided with a direct drive, propeller type fan driven by a motor with permanently lubricated bearings. The condenser coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing. Refrigerant flow from the condenser shall be controlled by means of a meter orifice. The compressor shall be a high performance rotary equipped with an internal thermal overload. The unit electrical power shall be as indicated on the contract drawings.
- H. The unit shall be provided with a factory furnished unit controller. Back-lit remote controller shall be capable of switching between cooling and heating (if applicable) modes as required to maintain temperature setpoint. Controller shall also include low ambient cooling and BACnet and Modbus interface for connection to the central BAS.

### PART 3 - EXECUTION

#### 3.1 GENERAL

- A. Install all equipment in accordance with manufacturer's printed instructions and as indicated. Provide all required utilities, wiring, and accessories indicated or required. Properly test each piece of equipment to assure proper operation and demonstrate same to Owner's designated representative. Remove and replace at no expense to the Owner any item of equipment deemed by the Architect to be unsatisfactory.
- B. Provide startup and adjustments for all systems and equipment in accordance with the manufacturer's recommendations using personnel who are factory trained and certified by factory as factory authorized personnel.

#### 3.2 STARTUP



- A. Verify that shipping, blocking, and bracing are removed.
- B. Verify that equipment is secure on mountings and supporting devices and that connections to piping, ductwork, and electrical systems are complete.
- C. Verify proper rotation and proper thermal-overload.
- D. Provide lubrication of all components with factory-recommended lubricants.
- E. Verify operating safeties are in place, piped or discharging to a safe location and functional prior to startup including but limited to the following:
  - 1. Electrical – Overloads installed, disconnects accessible, equipment covers and guards installed.
  - 2. Provide documentation of all pressure testing (piping, ductwork, and pressure vessels).
  - 3. Retouch any marred or scratched factory-finished surfaces with materials furnished by the manufacturer.

END OF SECTION 23 81 00

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## SECTION 23 82 00 - HEATING AND AIR CONDITIONING TERMINAL EQUIPMENT

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. Section includes:
  - 1. Unit Heaters
  - 2. Cabinet Unit Heaters
  - 3. Finned tube Radiation.

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with section 23 00 50.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include plans, elevations, sections, and mounting or attachment details.
  - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams for power, signal, and control wiring.
  - 5. Operation and maintenance manuals.

#### 1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

### PART 2 - PRODUCTS

## 2.1 UNIT HEATERS

- A. Unit heaters shall be as manufactured by Trane, Sterling, Airtherm, Engineered Air, or approved equal. Casing shall be 18 gauge steel finished with a baked enamel paint. Back panel shall be removable to provide coil access.
- B. Fan shall be of the propeller design with aluminum blades. Fan motor shall be totally enclosed; permanently lubricated with built-in overload protection.
- C. Hot water coil shall be copper tube of the single tube serpentine design with flat aluminum blades mechanically bonded to copper tubes. Coil shall be leak tested at 300 psig.
- D. Coil shall be tested and rate in accordance with ASHRAE 33.
- E. Units designed for horizontal applications shall be equipped with adjustable discharge louvers. Vertical units shall be equipped with conical diffuser.
- F. Refer to schedule for indicated thermostat/control/speed switch requirements.

## 2.2 CABINET UNIT HEATERS

- A. Cabinet heaters shall be as manufactured by Trane, Carrier, Markel, Airtherm, or Sterling, in compliance with AHRI 440.
- B. Cabinets shall be constructed of minimum 16 gauge front panels and minimum, 18 gauge end and top panels. Integral stamped, inlet and outlet grilles shall have 15° downward deflection. Front panel shall be insulated over the entire coil section. Hinged access door and front panel shall have cam locked fasteners. Cabinet parts shall be cleaned, bonderized, phosphatized and painted with baked enamel. Color as selected by Architect.
- C. Hot water coils shall be copper tubes with flat aluminum fins mechanically bonded. Coils shall be leak tested at 300 psig. Supply and return pipe connections shall be at the same end.
- D. Refer to the schedule on the drawings for the cabinet unit heater configuration.
- E. Filters shall be 1" replaceable with a MERV 8 rating in accordance with ASHRAE 52.2.
- F. Fans shall be forward-curved, double width centrifugal type with electronically commutated motors equipped with built-in overload protection. Unit shall be equipped with unit mounted three-speed fan switch and detachable motor cords. All wiring shall be in accordance with the National Electrical Code and shall be U.L. listed.

## 2.3 FINNED TUBE RADIATION

- A. Furnish and install fin tube radiation with capacity and continuous wall-to-wall enclosure lengths as indicated on the drawings. Contractor shall furnish detailed shop drawings for approval. Hot water finned tube radiation shall be Zehnder Rittling, Vulcan, Sterling, or Slantfin.

- B. Factory-packaged units shall be constructed according to ASTM B42, B68, B88.
- C. Heating elements shall be copper fin with flat aluminum fins mechanically bonded. Elements shall be rated at the BTU/HR per linear foot indicated on the drawings. Elements shall be supported by bracket and saddle assembly.
- D. Provide all accessories required for the complete installation.
- E. Provide access doors at valves and vents.

### PART 3 - EXECUTION

#### 3.1 GENERAL

- A. Install all equipment in accordance with manufacturer's printed instructions and as indicated. Provide all required utilities, wiring, and accessories indicated or required. Properly test each piece of equipment to assure proper operation and demonstrate same to Owner's designated representative. Remove and replace at no expense to the Owner any item of equipment deemed by the Architect to be unsatisfactory.

#### 3.2 UNIT HEATER INSTALLATION

- A. Install unit heater to comply with NFPA 90A.
- B. Install unit heaters level and plumb. Install piping to allow service and maintenance.
- C. Suspend unit heaters from structure with all-thread hanger rods and vibration isolators.
- D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

#### 3.3 FINNED TUBE RADIATION INSTALLATION

- A. Install units level and plumb.
- B. Install access doors for access to valves. Install valve within reach of access door provided.
- C. Install hanger brackets that allow for lengthwise movement of elements during expansion and contraction.

#### 3.4 START-UP

- A. Verify that shipping, blocking, and bracing are removed.
- B. Verify that equipment is secure on mountings and supporting devices and that connections to piping, ductwork, and electrical systems are complete.

- C. Verify proper rotation and proper thermal-overload.
- D. Provide lubrication of all components with factory-recommended lubricants.
- E. Verify operating safeties are in place, piped or discharging to a safe location and functional prior to startup including but limited to the following:
  - 1. Heating system – pressure vessel reliefs, high temperature shutdowns.
  - 2. Electrical – Overloads installed, disconnects accessible, equipment covers and guards installed.
  - 3. Provide documentation of all pressure testing (piping, ductwork, and pressure vessels).
  - 4. Protect all equipment/systems operating during temporary or start-up operation. Provide startup filtration (water/air), strainers (water) to protect equipment.
  - 5. Retouch any marred or scratched factory-finished surfaces with materials furnished by the manufacturer.

END OF SECTION 23 82 00

## SECTION 238413 – HUMIDIFIERS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements.

#### 1.2 SUMMARY

- A. This Section includes the following humidifiers:

- 1. Gas fired steam generator/humidifier.

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with section 23 00 50.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include plans, elevations, sections, and mounting or attachment details.
  - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams for power, signal, and control wiring.
  - 5. Operation and maintenance manuals.

#### 1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with ARI 640, "Commercial and Industrial Humidifiers."
- C. CSA certified.

## 1.5 COORDINATION

- A. Coordinate location and installation of humidifiers with manifolds in ducts and air-handling units or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

## PART 2 - PRODUCTS

### 2.1 GAS FIRED STEAM HUMIDIFIER

- A. Provide a packaged gas-fired steam generating system produces clean, sterile, atmospheric pressure steam through combustion of natural gas. Unit shall be CSA certified and rated in accordance with ARI 640.
- B. Enclosed cabinet, powder painted steel construction and air gap between cabinet and insulated humidifier tank ensures safe surface temperature.
- C. All internal components compatible with De-Ionized (DI), Reverse Osmosis (RO), potable and softened water.
- D. All tank surfaces shall be insulated with minimum 0.5" (12 mm) thick insulation and enclosed within unit cabinetry to ensure safe surface temperature, high overall efficiency, and fast unit response time. Units with exposed insulation shall not be acceptable.
- E. Standard internal drain water cooler to ensure drain water tempering to 140° F (60° C).
- F. Blow-down p-trap, factory installed, enclosed in cabinet, prevents steam leakage to drain. Field installation not acceptable.
- G. Humidifier to prevent "back-siphoning" using an internal air gap for supply water, to meet local plumbing codes.
- H. Drain line to include a vacuum breaker to prevent siphon drainage of the tank.
- I. Stainless Steel combustion chamber(s)/heat exchanger(s) shall be type 316 and tubular in design.
- J. Each burner, capable of true modulation at a 5:1 ratio.
- K. Unit shall be rated as a condensing, high-efficiency gas appliance with a secondary heat exchanger and condensate removal.
- L. Gas system with gas valve(s), explosion proof, premix combustion air blower(s), microprocessor controlled ignition, flame sensing and fault indicator light(s), 100% premix flat burner(s), spark igniters(s) and heat transfer efficiency maintained over all operating ranges.
- M. A secondary combustion air safety, in addition to blower speed monitoring, utilizing a mechanical pressure differential switch, to ensure combustion air is entering the pre-mix blower properly.



- N. Removable cover at front of unit facilitates easy cleaning (when applicable) with complete access to tank and heat exchanger surfaces. When removed, access must extend to the bottom of the tank with no lip.
- O. Automatic water level control within a separate float chamber, isolated from the boiling action, to prevent false water level indication.
- P. Dual magnetic electronic float system, located outside of the boiling water to ensure accurate water level control and reduced maintenance. Cool fill water is to be supplied into the assembly to keep the device cool. Systems using conductivity probes or floats located within boiling reservoir water are not acceptable.
- Q. Humidifier shall have a dual fill valve to feed water to the fill assembly, to reduce scaling and mineral build up on the magnetic floats.
- R. Unit shall have BACnet communication capability.
- S. Integrated Controller with LCD touchscreen and backlit display.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.
- B. Seal humidifier manifold duct or plenum penetrations with flange.
- C. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- D. Install stainless-steel drain pan under each manifold mounted in duct.
  - 1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
  - 2. Connect to condensate trap and drainage piping.
  - 3. Extend drain pan upstream and downstream from manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.
- E. Install manifold supply piping pitched to drain condensate back to humidifier.
- F. Comply with requirements for vibration isolation devices specified in Section 230050.
- G. Install piping adjacent to humidifiers to allow service and maintenance.
- H. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.
- I. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.

- J. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 84 13

## SECTION 23 86 00 - HVAC ACCESSORIES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. The commissioning process applies to all portions of this specification section. Commissioning is a formal process to thoroughly document the installation and verify the operation of building systems. Refer to Section 01 91 13 General Commissioning Requirements

#### 1.2 SUMMARY

- A. Section includes the following equipment:

- 1. UV Lights

#### 1.3 SUBMITTALS

- A. Submit shop drawings for all materials specified in this section in accordance with section 230050.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the product.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Include plans, elevations, sections, and mounting or attachment details.
  - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 4. Include diagrams for power, signal, and control wiring.
  - 5. Operation and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 MODULAR UV LAMPING SYSTEM

- A. UVC lamp and fixture shall be factory-assembled and tested. The system shall consist of a housing, reflector, power source, emitter sockets and emitter tube. All components shall be constructed to withstand typical HVAC environments and shall be UL listed under UL Standard 1995.
- B. Housing shall be constructed of Type 304 stainless steel and shall be equipped with electrical connectors on both ends to facilitate simple fixture to fixture plug-in (coupling) for A/C power. Fixtures shall be used as built-up or as side access, as required or as shown in the plans. Each fixture shall incorporate all components into one integral assembly that maximizes

serviceability. Fixtures shall be designed to be mounted anywhere in an HVAC system or as shown on the plans.

- C. Power source shall be electronic, high efficiency 120V, 208V, or 277V 1 phase / 60 Hz and shall be designed to maximum radiance and reliability at temperatures of 45-170°F. Power source shall include RF and EMI suppression.
- D. Sockets shall be medium bi-pin, single click safety, twist lock type and shall be constructed of a UVC-resistant polycarbonate.
- E. Emitter shall be high-output, hot cathode, T5 diameter, medium bi-pin type that produced UVGI of 254 nm. Total output per one inch arc length shall not be less than 10 MW cm<sup>2</sup> at one meter in a 400 feet per minute air stream of 45°F. Each tube shall produce the specified output at airflow velocities up to 1000 fpm and air temperature of 55-170°F.
- F. System shall be provided with a safety door switch to turn off lights when access door is opened, and J-box and stationary radiometer.
- G. Reflector shall be constructed of high spectral finished aluminum alloy with minimum 85% reflectance of 254 nm UVC energy.
- H. UVC System shall be Sterile Aire, model DE, UVDI model ALTRU-V, (V-Mod) or approved equal.

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. Install all equipment in accordance with manufacturer's printed instructions and as indicated. Provide all required utilities, wiring, and accessories indicated or required. Properly test each piece of equipment to assure proper operation and demonstrate same to Owner's designated representative. Remove and replace at no expense to the Owner any item of equipment deemed by the Architect to be unsatisfactory.
- B. Provide start-up and adjustments for all systems and equipment in accordance with the manufacturer's recommendations using personnel who are factory trained and certified by factory as factory authorized personnel.

### 3.2 START-UP COMMISSIONING

- A. Verify that shipping, blocking, and bracing are removed.
- B. Verify that equipment is secure on mountings and supporting devices and that connections to piping, ductwork, and electrical systems are complete.
- C. Verify operating safeties are in place, piped or discharging to a safe location and functional prior to startup including but limited to the following:
- D. Electrical – Overloads installed, disconnects accessible, equipment covers and guards installed.

- E. Protect all equipment/systems operating during temporary or start-up operation.
- F. Retouch any marred or scratched factory-finished surfaces with materials furnished by the manufacturer.

END OF SECTION 23 86 00