

## **SECTION 23 02 00 - BASIC MATERIALS AND METHODS**

### **PART 1 - GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. The requirements of the General Conditions and Supplementary Conditions apply to all Work herein.
- B. The Contract Drawings indicate the extent and general arrangement of the systems. If any departure from the Contract Drawings is deemed necessary by the Contractor, details of such departures and the reasons therefore, shall be submitted to the Architect/Engineer for review as soon as practicable. No such departures shall be made without the prior written approval of the Architect/Engineer.
- C. Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form or type of construction by name, make or catalog number, such reference shall not be construed as limiting competition; and the Contractor, in such cases, may at his option use any article, device, product, material, fixture, form or type of construction which in the judgment of the Architect/Engineer, expressed in writing, is the equivalent of that specified.

#### **1.2 SCOPE OF WORK**

- A. The Work included under this Contract consists of the furnishing and installation of all equipment and material necessary and required to form complete and functioning systems in all of their various phases, all as shown on the accompanying Drawings and/or described in these Specifications. The Contractor shall review all pertinent drawings, including those of other contracts, prior to commencement of Work.
- B. This Division requires the furnishing and installing of all items as specified herein, indicated on the Drawings or reasonably inferred as necessary for safe and proper operation; including every article, device or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the work include, but are not limited to, materials, labor, supervision, transportation, storage, equipment, utilities, all required permits, licenses and inspections. All work performed under this Section shall be in accordance with the Project Manual, Drawings and Specifications and is subject to the terms and conditions of the Contract.
- C. The approximate locations of Mechanical (HVAC) items are indicated on the Drawings. These Drawings are not intended to give complete and accurate details in regard to location of outlets, apparatus, etc. Exact locations are to be determined by actual measurements at the building, and will in all cases be subject to the review of the Owner or Engineer, who reserves the right to make any reasonable changes in the locations indicated without additional cost to the Owner.
- D. Items specifically mentioned in the Specifications but not shown on the Drawings and/or items shown on Drawings but not specifically mentioned in the Specifications shall be installed by the Contractor under the appropriate section of work as if they were both specified and shown.
- E. All discrepancies between the Contract Documents and actual job-site conditions shall be reported to the Owner or Engineer so that they will be resolved prior to bidding. Where this cannot be done at least 7 working days prior to bid; the greater or more costly of the

discrepancy shall be bid. All labor and materials required to perform the work described shall be included as part of this Contract.

- F. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and fully operating system in cooperation with other trades.
- G. It is the intent of the above "Scope" to give the Contractor a general outline of the extent of the Work involved; however, it is not intended to include each and every item required for the Work. Anything omitted from the "Scope" but shown on the Drawings, or specified later, or necessary for a complete and functioning heating, ventilating and air conditioning system shall be considered a part of the overall "Scope".
- H. The Contractor shall rough-in fixtures and equipment furnished by others from rough-in and placement drawings furnished by others. The Contractor shall make final connection to fixtures and equipment furnished by others.
- I. The Contractor shall participate in the commissioning process as required; including, but not limited to, meeting attendance, completion of checklists, and participation in functional testing.

### 1.3 SCHEMATIC NATURE OF CONTRACT DOCUMENTS

- A. The Contract Documents are schematic in nature in that they are only to establish scope and a minimum level of quality. They are not to be used as actual working construction drawings. The actual working construction drawings shall be the reviewed shop drawings.
- B. All duct or pipe or equipment locations as indicated on the documents do not indicate every transition, offset, or exact location. All transitions, offsets, clearances and exact locations shall be established by actual field measurements, coordination with the structural, architectural and reflected ceiling plans, and other trades. Submit shop drawings for review.
- C. All transitions, offsets and relocations as required by actual field conditions shall be performed by the Contractor at no additional cost to the Owner.
- D. Additional coordination with electrical contractor may be required to allow adequate clearances of electrical equipment, fixtures and associated appurtenances. Contractor to notify Architect and Engineer of unresolved clearances, conflicts or equipment locations.

### 1.4 SITE VISIT AND FAMILIARIZATION

- A. Before submitting a bid, it will be necessary for each Contractor whose work is involved to visit the site and ascertain for himself the conditions to be met therein in installing his work and make due provision for same in his bid. It will be assumed that this Contractor in submitting his bid has visited the premises and that his bid covers all work necessary to properly install the equipment shown. Failure on the part of the Contractor to comply with this requirement shall not be considered justification for the omission or faulty installation of any work covered by these Specifications and Drawings.
- B. Understand the existing utilities from which services will be supplied; verify locations of utility services, and determine requirements for connections.
- C. Determine in advance that equipment and materials proposed for installation fit into the confines indicated.

1.5 WORK SPECIFIED IN OTHER SECTIONS

- A. Finish painting is specified. Prime and protective painting are included in the work of this Division.
- B. Owner and General Contractor furnished equipment shall be properly connected to Mechanical (HVAC) systems.
- C. Furnishing and installing all required Mechanical (HVAC) equipment control relays and electrical interlock devices, conduit, wire and J-boxes are included in the Work of this Division.

1.6 PERMITS, TESTS, INSPECTIONS

- A. Arrange and pay for all permits, fees, tests, and all inspections as required by governmental authorities.

1.7 DATE OF SUBSTANTIAL COMPLETION

- A. The date of final acceptance shall be the date of substantial completion. Refer to Division One for additional requirements.
- B. The date of final acceptance shall be documented in writing and signed by the Architect, Owner and Contractor.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
- B. Deliver products to the project at such time as the project is ready to receive the equipment, pipe or duct - properly protected from incidental damage and weather damage.
- C. Damaged equipment, duct or pipe shall be promptly removed from the site and new, undamaged equipment, pipe or duct shall be installed in its place promptly with no additional charge to the Owner.

1.9 NOISE AND VIBRATION

- A. The heating, ventilating and air conditioning systems, and the component parts thereof, shall be guaranteed to operate without objectionable noise and vibration.
- B. Provide foundations, supports and isolators as specified or indicated, properly adjusted to prevent transmission of vibration to the building structure, piping and other items.
- C. Carefully fabricate ductwork and fittings with smooth interior finish to prevent turbulence and generation or regeneration of noise.
- D. All equipment shall be selected to operate with minimum of noise and vibration. If, in the opinion of the Architect, objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of the Work, the Contractor shall rectify such conditions without extra cost to the Owner.

#### 1.10 APPLICABLE CODES AND STANDARDS

- A. Obtain all required permits and inspections for all work required by the Contract Documents and pay all required fees in connection thereof.
- B. Arrange with the serving utility companies for the connection of all required utilities and pay all charges, meter charges, connection fees and inspection fees, if required.
- C. Comply with all applicable codes, specifications, local ordinances, industry standards, utility company regulations and the applicable requirements which includes and is not limited to the following nationally accepted codes and standards:
  - 1. Air Moving & Conditioning Association, AMCA.
  - 2. American Standards Association, ASA.
  - 3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., ASHRAE.
  - 4. American Society of Mechanical Engineers, ASME.
  - 5. American Society of Plumbing Engineers, ASPE.
  - 6. American Society of Testing Materials, ASTM.
  - 7. American Water Works Association, AWWA.
  - 8. National Bureau of Standards, NBS.
  - 9. National Fire Protection Association, NFPA.
  - 10. Sheet Metal & Air Conditioning Contractors' National Association, SMACNA.
  - 11. Underwriters' Laboratories, Inc., UL.
  - 12. International Energy Conservation Code, IECC.
  - 13. International Building Code.
  - 14. International Mechanical Code.
  - 15. International Fire Code.
  - 16. International Gas Code.
- D. Where differences existing between the Contract Documents and applicable state or city building codes, state and local ordinances, industry standards, utility company regulations and the applicable requirements of the nationally accepted codes and standards, the more stringent or costly application shall govern. Promptly notify the Engineer in writing of all differences.
- E. When directed in writing by the Engineer, remove all work installed that does not comply with the Contract Documents and applicable state or city building codes, state and local ordinances, industry standards, utility company regulations and the applicable requirements of the above listed nationally accepted codes and standards, correct the deficiencies, and complete the work at no additional cost to the Owner.

#### 1.11 DEFINITIONS AND SYMBOLS

- A. General Explanation: A substantial amount of construction and Specification language constitutes definitions for terms found in other Contract Documents, including Drawings which must be recognized as diagrammatic and schematic in nature and not completely descriptive of requirements indicated thereon. Certain terms used in Contract Documents are defined generally in this article, unless defined otherwise in Division 01.
- B. Definitions and explanations of this Section are not necessarily either complete or exclusive, but are general for work to the extent not stated more explicitly in another provision of the Contract Documents.
- C. Indicated: The term "Indicated" is a cross-reference to details, notes or schedules on the

Drawings, to other paragraphs or schedules in the Specifications and to similar means of recording requirements in Contract Documents. Where such terms as "Shown", "Noted", "Scheduled", "Specified" and "Detailed" are used in lieu of "Indicated", it is for the purpose of helping the reader locate cross-reference material, and no limitation of location is intended except as specifically shown.

- D. Directed: Where not otherwise explained, terms such as "Directed", "Requested", "Accepted", and "Permitted" mean by the Architect or Engineer. However, no such implied meaning will be interpreted to extend the Architect's or Engineer's responsibility into the Contractor's area of construction supervision.
- E. Reviewed: Where used in conjunction with the Engineer's response to submittals, requests for information, applications, inquiries, reports and claims by the Contractor the meaning of the term "Reviewed" will be held to limitations of Architect's and Engineer's responsibilities and duties as specified in the General and Supplemental Conditions. In no case will "Reviewed" by Engineer be interpreted as a release of the Contractor from responsibility to fulfill the terms and requirements of the Contract Documents.
- F. Furnish: Except as otherwise defined in greater detail, the term "Furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, etc., as applicable in each instance.
- G. Install: Except as otherwise defined in greater detail, the term "Install" is used to describe operations at the project site including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance.
- H. Provide: Except as otherwise defined in greater detail, the term "Provide" is used to mean "Furnish and Install", complete and ready for intended use, as applicable in each instance.
- I. Installer: Entity (person or firm) engaged by the Contractor, or its Subcontractor or Sub-subcontractor for performance of a particular unit of work at the project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance. It is a general requirement that such entities (Installers) be expert in the operations they are engaged to perform.
- J. Imperative Language: Used generally in Specifications. Except as otherwise indicated, requirements expressed imperatively are to be performed by the Contractor. For clarity of reading at certain locations, contrasting subjective language is used to describe responsibilities that must be fulfilled indirectly by the Contractor or, when so noted, by other identified installers or entities.
- K. Minimum Quality/Quantity: In every instance, the quality level or quantity shown or specified is intended as minimum quality level or quantity of work to be performed or provided. Except as otherwise specifically indicated, the actual work may either comply exactly with that minimum (within specified tolerances), or may exceed that minimum within reasonable tolerance limits. In complying with requirements, indicated or scheduled numeric values are either minimums or maximums as noted or as appropriate for the context of the requirements. Refer instances of uncertainty to Owner or Engineer via a request for information (RFI) for decision before proceeding.
- L. Abbreviations and Symbols: The language of Specifications and other Contract Documents including Drawings is of an abbreviated type in certain instances, and implies

words and meanings which will be appropriately interpreted. Actual word abbreviations of a self-explanatory nature have been included in text of Specifications and Drawings. Specific abbreviations and symbols have been established, principally for lengthy technical terminology and primarily in conjunction with coordination of Specification requirements with notations on Drawings and in Schedules. These are frequently defined in Section at first instance of use or on a Legend and Symbol Drawing. Trade and industry association names and titles of generally recognized industry standards are frequently abbreviated. Singular words will be interpreted as plural and plural words will be interpreted as singular where applicable and where full context of Contract Documents so indicate. Except as otherwise indicated, graphic symbols and abbreviations used on Drawings and in Specifications are those recognized in construction industry for indicated purposes. Where not otherwise noted symbols and abbreviations are defined by the latest ASHRAE Fundamentals Handbook, chapter 34 "Abbreviations and Symbols", ASME and ASPE published standards.

#### 1.12 DRAWINGS AND SPECIFICATIONS

- A. These Specifications are intended to supplement the Drawings and it will not be the province of the Specifications to mention any part of the Work which the Drawings are competent to fully explain in every particular and such omission is not to relieve the Contractor from carrying out portions indicated on the Drawings only.
- B. Should items be required by these Specifications and not indicated on the Drawings, they are to be supplied even if of such nature that they could have been indicated thereon. In case of disagreement between Drawings and Specifications, or within either Drawings or Specifications, the better quality or greater quantity of work shall be estimated and the matter referred to the Architect or Engineer for review with a request for information and clarification at least 7 working days prior to bid opening date for issuance of an addendum.
- C. The listing of product manufacturers, materials and methods in the various sections of the Specifications, and indicated on the Drawings, is intended to establish a standard of quality only. It is not the intention of the Owner or Engineer to discriminate against any product, material or method that is the equivalent of the standards as indicated and/or specified, nor is it intended to preclude open, competitive bidding. The fact that a specific manufacturer is listed as an acceptable manufacturer should not be interpreted to mean that the manufacturer's standard product will meet the requirements of the project design, Drawings, Specifications and space constraints.
- D. The Architect or Engineer and Owner shall be the sole judge of quality and equivalence of equipment, materials and methods.
- E. Products by other reliable manufacturers, other materials, and other methods, will be accepted as outlined, provided they have equivalent capacity, construction, and performance. However, under no circumstances shall any substitution be made without the written permission of the Architect or Engineer and Owner. Request for prior approval must be made in writing 10 calendar days prior to the bid date without fail.
- F. Wherever a definite product, material or method is specified and there is not a statement that another product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method is the only one that shall be used without prior approval.
- G. Wherever a definite material or manufacturer's product is specified and the Specification states that products of similar design and equivalent construction from the specified list of

manufacturers may be substituted, it is the intention of the Owner or Engineer that products of manufacturers that are specified are the only products that will be acceptable and that products of other manufacturers will not be considered for substitution without approval.

- H. Wherever a definite product, material or method is specified and there is a statement that "OR EQUIVALENT" product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method or an "OR EQUIVALENT" product, material or method may be used if it complies with the Specifications and is submitted for review to the Engineer as outline herein.
- I. Where permission to use substituted or alternative equipment on the project is granted by the Owner or Engineer in writing, it shall be the responsibility of the Contractor or Subcontractor involved to verify that the equipment will fit in the space available which includes allowances for all required Code and maintenance clearances, and to coordinate all equipment structural support, plumbing and electrical requirements and provisions with the Mechanical (HVAC) Design Documents and all other trades, including Division 26.
- J. Changes in architectural, structural, electrical, mechanical, and plumbing requirements for the substitution shall be the responsibility of the bidder wishing to make the substitution. This shall include the cost of redesign by the affected designer(s). Any additional cost incurred by affected Subcontractors shall be the responsibility of this bidder and not the Owner.
- K. If any request for a substitution of product, material or method is rejected, the Contractor will automatically be required to furnish the product, material or method named in the Specifications. Repetitive requests for substitutions will not be considered.
- L. The Owner or Engineer will investigate all requests for substitutions when submitted in accordance with the requirements listed above; and if accepted, will issue a letter allowing the substitutions.
- M. Where equipment other than that used in the design as specified or shown on the Drawings is substituted (either from an approved manufacturers list or by submittal review), it shall be the responsibility of the substituting Contractor to coordinate space requirements, building provisions and connection requirements with his trades and all other trades; and to pay all additional costs to other trades, the Owner, the Architect or Engineer, if any, due to the substitutions.

### 1.13 SUBMITTALS

- A. Coordinate with Division 01 for submittal timetable requirements, unless noted otherwise within thirty (30) days after the Contract is awarded. The Contractor shall submit an electronic copy of a complete set of shop drawings and complete data covering each item of equipment or material. The submittal of each item requiring a submittal must be received by the Architect or Engineer within the above thirty-day period. The Architect or Engineer shall not be responsible for any delays or costs incurred due to excessive shop drawing review time for submittals received after the thirty (30) day time limit. The Architect and Engineer will retain a copy of all shop drawings for their files. All literature pertaining to items subject to Shop Drawing submittal shall be submitted at one time. Submittals shall be placed in one electronic file in PDF 8.0 format and bookmarked for individual specification sections. Individual electronic files of submittals for individual specifications shall not be permitted. Each submittal shall include the following items:

1. A cover sheet with the names and addresses of the Project, Architect, MEP Engineer, General Contractor and the Subcontractor making the submittal. The cover sheet shall also contain the section number covering the item or items submitted and the item nomenclature or description.
  2. An index page with a listing of all data included in the Submittal.
  3. A list of variations page with a listing of all variations, including unfurnished or additional required accessories, items or other features, between the submitted equipment and the specified equipment. If there are no variations, then this page shall state "NO VARIATIONS". Where variations affect the work of other Contractors, then the Contractor shall certify on this page that these variations have been fully coordinated with the affected Contractors and that all expenses associated with the variations will be paid by the submitting Contractor. This page will be signed by the submitting Contractor.
  4. Equipment information including manufacturer's name and designation, size, performance and capacity data as applicable. All applicable Listings, Labels, Approvals and Standards shall be clearly indicated.
  5. Dimensional data and scaled drawings as applicable to show that the submitted equipment will fit the space available with all required Code and maintenance clearances clearly indicated and labeled at a minimum scale of 1/4" = 1'-0", as required to demonstrate that the alternate or substituted product will fit in the space available.
  6. Identification of each item of material or equipment matching that indicated on the Drawings.
  7. Sufficient pictorial, descriptive and diagrammatic data on each item to show its conformance with the Drawings and Specifications. Any options or special requirements or accessories shall be so indicated. All applicable information shall be clearly indicated with arrows or another approved method.
  8. Additional information as required in other Sections of this Division.
  9. Certification by the General Contractor and Subcontractor that the material submitted is in accordance with the Drawings and Specifications, signed and dated in long hand. Submittals that do not comply with the above requirements shall be returned to the Contractor and shall be marked "REVISE AND RESUBMIT".
- B. Refer to Division 00 and Division 01 for additional information on shop drawings and submittals.
- C. Equipment and materials submittals and shop drawings will be reviewed for compliance with design concept only. It will be assumed that the submitting Contractor has verified that all items submitted can be installed in the space allotted. Review of shop drawings and submittals shall not be considered as a verification or guarantee of measurements or building conditions.
- D. Where shop drawings and submittals are marked "REVIEWED", the review of the submittal does not indicate that submittals have been checked in detail nor does it in any way relieve the Contractor from his responsibility to furnish material and perform work as required by the Contract Documents.
- E. Shop drawings shall be reviewed and returned to the Contractor with one of the following categories indicated:
1. REVIEWED: Contractor need take no further submittal action, shall include this submittal in the O&M manual and may order the equipment submitted on.
  2. REVIEWED AS NOTED: Contractor shall submit a letter verifying that required exceptions to the submittal have been received and complied with including

- additional accessories or coordination action as noted, and shall include this submittal and compliance letter in the O&M manual. The contractor may order the equipment submitted on at the time of the returned submittal providing the Contractor complies with the exceptions noted.
3. NOT APPROVED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is not approved. The Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or Drawings. Contractor shall not order equipment that is not approved. Repetitive requests for substitutions will not be considered.
  4. REVISE AND RESUBMIT: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked revise and resubmit. The Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or provide as noted on previous shop drawings. Contractor shall not order equipment marked revise and resubmit. Repetitive requests for substitutions will not be considered.
  5. CONTRACTOR'S CERTIFICATION REQUIRED: Contractor shall resubmit submittal on material, equipment or method of installation. The Contractor's stamp is required stating that the submittal meets all conditions of the Contract Documents. The stamp shall be signed by the General Contractor. The submittal will not be reviewed if the stamp is not placed and signed on all shop drawings.
  6. MANUFACTURER NOT AS SPECIFIED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked manufacturer not as specified. The Contractor will automatically be required to furnish the product, material or method named in the Specifications. Contractor shall not order equipment when submittal is marked manufacturer not as specified. Repetitive requests for substitutions will not be considered.
- F. Materials and equipment which are purchased or installed without submittal review shall be at the risk of the Contractor and the cost for removal and replacement of such materials and equipment and related work which is judged unsatisfactory by the Owner or Engineer for any reason shall be at the expense of the Contractor. The responsible Contractor shall remove the material and equipment noted above and replace with specified equipment or material at his own expense when directed in writing by the Architect or Engineer.
- G. Shop Drawing Submittals shall be complete and checked prior to submission to the Engineer for review.
- H. Submittals are required for, but not limited to, the following items subject to project requirements:
1. Coordination Drawings
  2. Common Motor Requirements for HVAC Equipment
  3. Expansion Fittings and Loops for HVAC Piping
  4. Variable Frequency Motor Speed Control for HVAC Equipment
  5. Hangers and Support for Piping and Equipment HVAC
  6. Vibration and Seismic Controls for HVAC Piping and Equipment
  7. Testing, Adjusting, and Balancing
  8. Duct Insulation
  9. HVAC Equipment Insulation
  10. HVAC Piping Insulation
  11. Refrigerant Monitor System

12. Energy Management and Control System
13. Above Ground Hydronic Piping
14. Hydronic Specialties
15. Hydronic Pumps
16. Refrigerant Piping
17. Metal Ductwork
18. Ductwork Accessories
19. HVAC Fans
20. Series Fan Powered Terminal Units
21. Single Duct VAV Terminal Box
22. Parallel Fan Powered Terminal Unit
23. Dual Duct Air Terminal Units
24. Air Distribution Devices
25. Air Filters
26. Flue Pipe Systems
27. Non-Condensing Boiler-Gas Fired (Forced Draft)
28. Condensing Boiler – Gas Fired
29. Finned Water-Tube Boilers
30. Steel Water-Tube Boilers
31. Gas Fired Furnaces
32. Gas Fired Roof Mounted Make-up Air Unit Heaters
33. Shell and Tube Heat Exchanger
34. Centrifugal Liquid Chiller
35. Rotary Screw Water Chillers
36. Air Cooled Rotary Liquid Chiller
37. Induced Draft Cooling Tower
38. Energy Recovery Ventilator
39. Modular Indoor Central Station Air Handling Units
40. Packaged Air Handling Unit
41. Modular Outdoor Central Station Air Handling Units
42. 100% Outside Air Rooftop Unit with Gas Heat
43. Self-Contained Air Conditioners
44. Rooftop Heating and Cooling Units Electric Cooling-Gas Heating
45. Rooftop Heating and Cooling Units Electric Cooling-Electric Heat
46. Variable Air Volume Rooftop Units
47. Variable Refrigerant Flow (VRF) for HVAC System
48. Water Source Heat Pump Unit
49. Fan Coil Unit
50. Unit Ventilators
51. Electric Duct Heaters
52. Radiant Heating Electric Cables
53. Air Conditioning Unit for Swimming Pool Enclosures

- I. Refer to other Division 23 sections for additional submittal requirements. Provide samples of actual materials and/or equipment to be used on the Project upon request of the Owner or Engineer.

#### 1.14 COORDINATION DRAWINGS

- A. Prepare coordination drawings to a scale of 1/4"=1'-0" or larger; detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access, and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of pipe, duct, equipment, and other materials. Include the following:
    - a. Wall and type locations.
    - b. Clearances for installing and maintaining insulation.
    - c. Locations of light fixtures and sprinkler heads.
    - d. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
    - e. Equipment connections and support details.
    - f. Exterior wall and foundation penetrations.
    - g. Routing of storm and sanitary sewer piping.
    - h. Fire-rated wall and floor penetrations.
    - i. Sizes and location of required concrete pads and bases.
    - j. Valve stem movement.
    - k. Structural floor, wall and roof opening sizes and details.
  2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
  3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
  4. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.
- B. This Contractor shall be responsible for coordination of all items that will affect the installation of the work of this Division. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.
- C. By submitting coordination drawings on the project, this Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all other Contractors and Subcontractors.

#### 1.15 RECORD DOCUMENTS

- A. Prepare Record Documents in accordance with the requirements in Special Project Requirements, in addition to the requirements specified in Division 23, indicate the following installed conditions:
1. Duct mains and branches, size and location, for both exterior and interior; locations of dampers, fire dampers, duct access panels, and other control devices; filters, fuel fired heaters, fan coils, condensing units, and roof-top A/C units requiring periodic maintenance or repair.
  2. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Indicate actual inverts and horizontal locations of underground piping.
  3. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
  4. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
  5. Contract Modifications, actual equipment and materials installed.

- B. Engage the services of a Land Surveyor or Professional Engineer registered in the state in which the project is located as specified herein to record the locations and invert elevations of underground installations.
- C. The Contractor shall maintain a set of clearly marked black line record "AS-BUILT" prints on the job site on which he shall mark all work details, alterations to meet site conditions and changes made by "Change Order" notices. These shall be kept available for inspection by the Owner, Architect or Engineer at all times.
- D. Refer to Division 00 and Division 01 for additional requirements concerning Record Drawings. If the Contractor does not keep an accurate set of as-built drawings, the pay request may be altered or delayed at the request of the Architect. Mark the drawings with a colored pencil. Delivery of as-built prints and re-producibles is a condition of substantial completion.
- E. The record prints shall be updated on a daily basis and shall indicate accurate dimensions for all buried or concealed work, precise locations of all concealed pipe or duct, locations of all concealed valves, controls and devices and any deviations from the work shown on the Construction Documents which are required for coordination. All dimensions shall include at least two dimensions to permanent structure points.
- F. Submit three prints of the tracings for review. Make corrections to tracings as directed and deliver "Auto Positive Tracings" to the Architect. "As-Built" drawings shall be furnished in addition to submittals.
- G. When the option described in paragraph F above is not exercised, then upon completion of the Work, the Contractor shall transfer all marks from the tracings and submit a set of clear concise reproducible record "AS-BUILT" drawings and shall submit the reproducible drawings with corrections made by a competent draftsman and three (3) sets of black line prints to the Architect or Engineer for review prior to scheduling the final inspection at the completion of the Work. The reproducible record "AS-BUILT" drawings shall have the Engineer's Name and Seal removed or blanked out and shall be clearly marked and signed on each sheet as follows:

CERTIFIED RECORD DRAWINGS

DATE:

(NAME OF GENERAL CONTRACTOR)

BY: \_\_\_\_\_  
(SIGNATURE)

(NAME OF SUBCONTRACTOR)

BY: \_\_\_\_\_  
(SIGNATURE)

1.16 OPERATING AND MAINTENANCE MANUALS

- A. Prepare operating and maintenance manuals in accordance with Division 00 and Division 01 and, in addition to the requirements specified in those Divisions, include the following information for equipment items:
  - 1. Description of function, normal operating characteristics and limitations,

- performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
  3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
  4. Servicing instructions and lubrication charts and schedules.

#### 1.17 CERTIFICATIONS AND TEST REPORTS

- A. Submit a detailed schedule for completion and testing of each system indicating scheduled dates for completion of system installation and outlining tests to be performed and scheduled date for each test. This detailed completion and test schedule shall be submitted at least 90 days before the projected substantial completion date.
- B. Test result reporting forms shall be submitted for review no later than the date of the detailed schedule.
- C. Submit 4 copies of all certifications and test reports to the Architect or Engineer for review adequately in advance of substantial completion of the Work to allow for remedial action as required to correct deficiencies discovered in equipment and systems.
- D. Certifications and test reports to be submitted shall include, but not be limited to, those items outlined in Section 23 02 00.

#### 1.18 OPERATING AND MAINTENANCE MANUALS

- A. Coordinate with Division 00 and Division 01 for operating and maintenance manual requirements. Unless noted otherwise, bind together in "D ring type" binders (National model no. 79-883 or equal). Binders shall be large enough to allow  $\frac{1}{4}$ " of spare capacity. Three (3) sets of all reviewed submittals, fabrication drawings, bulletins, maintenance instructions, operating instructions and parts exploded views and lists for each and every piece of equipment furnished under these Specifications. All sections shall be typed and indexed into sections and labeled for easy reference and shall utilize the individual specification section numbers shown in the Mechanical Specifications as an organization guideline. Bulletins containing information about equipment that is not installed on the project shall be properly marked up or stripped and reassembled. All pertinent information required by the Owner for proper operation and maintenance of equipment supplied by Division 23 shall be clearly and legibly set forth in memoranda that shall, likewise, be bound with bulletins.
- B. Prepare maintenance manuals in accordance with Special Project Conditions. In addition to the requirements specified in Division 23, include the following information for equipment items:
  1. Identifying names, name tag designations and locations for all equipment.
  2. Valve tag lists with valve number, type, color coding, location and function.
  3. Reviewed submittals with exceptions noted compliance letter.
  4. Fabrication drawings.
  5. Equipment and device bulletins and data sheets clearly highlighted to show equipment installed on the project and including performance curves and data as applicable (i.e., description of function, normal operating characteristics and

limitations, performance curves, engineering data and tests, and complete nomenclature and model numbers of replacement parts).

6. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
  7. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions, servicing instructions and lubrication charts and schedules.
  8. Equipment and motor name plate data.
  9. Wiring diagrams.
  10. Exploded parts views and parts lists for all equipment and devices.
  11. Color coding charts for all painted equipment and piping.
  12. Location and listing of all spare parts and special keys and tools furnished to the Owner.
  13. Furnish recommended lubrication schedule for all required lubrication points with listing of type and approximate amount of lubricant required.
- C. Refer to Division 00 and Division 01 for additional information on Operating and Maintenance Manuals.
- D. Operating and Maintenance Manuals shall be turned over to the Owner or Engineer for review a minimum of 14 working days prior to the beginning of the operator training period.

#### 1.19 OPERATOR TRAINING

- A. The Contractor shall furnish the services of factory trained specialists to instruct the Owner's operating personnel. The Owner's operator training shall include a minimum of 12 hours of onsite training in three 4 hour shifts.
- B. Before proceeding with the instruction of Owner Personnel, prepare a typed outline in triplicate, listing the subjects that will be covered in this instruction, and submit the outline for review by the Owner. At the conclusion of the instruction period, obtain the signature of each person being instructed on each copy of the reviewed outline to signify that he has a proper understanding of the operation and maintenance of the systems and resubmit the signed outlines.
- C. Refer to other Division 23 Sections for additional Operator Training requirements.

#### 1.20 FINAL COMPLETION

- A. At the completion of the Work, all equipment and systems shall be tested and faulty equipment and material shall be repaired or replaced. Refer to Sections of Division 23 for additional requirements.
- B. Clean and adjust all air distribution devices and replace all air filters immediately prior to Substantial Completion.
- C. Touch up and/or refinish all scratched equipment and devices immediately prior to Substantial Completion.

#### 1.21 CONTRACTOR'S GUARANTEE

- A. Use of the HVAC systems to provide temporary service during construction period will not

be allowed without permission from the Owner in writing; and, if granted, shall not cause the warranty period to start, except as defined below.

- B. Contractor shall guarantee to keep the entire installation in repair and perfect working order for a period of one year after the date of the Substantial Completion, and shall furnish (free of additional cost to the Owner) all materials and labor necessary to comply with the above guarantee throughout the year beginning from the date of Substantial Completion, Beneficial Occupancy by the Owner, or the Certificate of Final Payment as agreed upon by all parties.
- C. This guarantee shall not include cleaning or changing filters except as required by testing, adjusting and balancing.
- D. All air conditioning compressors shall have parts and labor guarantees for a period of not less than 5 years beyond the date of Substantial Completion.
- E. Refer to Sections in Division 23 for additional guarantee or warranty requirements.

## 1.22 TRANSFER OF ELECTRONIC FILES

- A. Project documents are not intended or represented to be suitable for reuse by Architect/Owner or others on extensions of this project or on any other project. Any such reuse or modification without written verification or adaptation by Engineer, as appropriate for the specific purpose intended, will be at Architect/Owner's risk and without liability or legal exposure to Engineer or its consultants from all claims, damages, losses and expense, including attorney's fees arising out of or resulting thereof.
- B. Because data stored in electronic media format can deteriorate or be modified inadvertently, or otherwise, without authorization of the data's creator, the party receiving the electronic files agrees that it will perform acceptance tests or procedures within sixty (60) days of receipt, after which time the receiving party shall be deemed to have accepted the data thus transferred to be acceptable. Any errors detected within the sixty (60) day acceptance period will be corrected by the party delivering the electronic files. Engineer is not responsible for maintaining documents stored in electronic media format after acceptance by the Architect/Owner.
- C. When transferring documents in electronic media format, Engineer makes no representations as to the long term compatibility, usability or readability of documents resulting from the use of software application packages, operating systems, or computer hardware differing from those used by Engineer at the beginning of the Project.
- D. Any reuse or modifications will be at the Contractor's sole risk and without liability or legal exposure to Architect, Engineer or any consultant.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

- A. Provide materials and equipment manufactured by a domestic United States manufacturer and assembled in the United States for all local and Federal Government projects. These materials and equipment shall comply with "Buy American Act."
- B. Access Doors: Provide access doors as required for access to equipment, valves, controls, cleanouts and other apparatus where concealed. Access doors shall have concealed hinges and screw driver cam locks.

- C. All access doors located in wet areas such as restrooms, locker rooms, shower rooms, kitchen and any other wet areas shall be constructed of stainless steel.
- D. Access Doors: shall be as follows:
  - 1. Plaster Surfaces: Milcor Style K.
  - 2. Ceramic Tile Surface: Milcor Style M.
  - 3. Drywall Surfaces: Milcor Style DW.
  - 4. Install doors only in locations approved by the Architect.

## 2.2 EQUIPMENT PADS (See 2.4 in Section 26 02 00)

### PART 3 - EXECUTION

#### 3.1 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected via reviewed submittals.
- B. Refer to equipment specifications in Divisions 2 through 48 for additional rough-in requirements.

#### 3.2 MECHANICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:
  - 1. Coordinate mechanical systems, equipment, and materials installation with other building components.
  - 2. Verify all dimensions by field measurements.
  - 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
  - 4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
  - 5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
  - 6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
  - 7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
  - 8. Install systems, materials, and equipment to conform with architectural action markings on submittal, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, resolve conflicts and submit proposed solution to the Architect for review.
  - 9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
  - 10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as possible, connect

- equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location and label.
11. Install access doors where units are concealed behind finished surfaces. Refer to paragraph 2.1 in this section and architect for access doors specifications and location.
  12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
  13. Provide roof curbs for all roof mounted equipment. Coordinate with roof construction for pitched roof. Provide roof curbs which match the roof slope and provides a level top for equipment installation. Refer to Architectural drawings and details.
  14. The equipment to be furnished under these Specifications shall be essentially the standard product of the manufacturer. Where two or more units of the same class of equipment are required, these units shall be products of a single manufacturer; however, the component parts of the system need not be the product of the same manufacturer.
  15. The Architectural and Structural features of the building and the space limitations shall be considered in selection of all equipment. No equipment shall be furnished which will not suit the arrangement and space limitations indicated.
  16. Lubrication: Prior to start-up, check and properly lubricate all bearings as recommended by the manufacturer.
  17. Where the word "Concealed" is used in these Specifications in connection with insulating, painting, piping, ducts, etc., it shall be understood to mean hidden from sight as in chases, furred spaces or suspended ceilings. "Exposed" shall be understood to mean the opposite of concealed.
  18. Identification of Mechanical Equipment:
    - a. Mechanical equipment shall be identified by means of nameplates permanently attached to the equipment. Nameplates shall be engraved laminated plastic or etched metal. Submittals shall include dimensions and lettering format for approval. Attachment shall be with escutcheon pins, self-tapping screws, or machine screws.
    - b. Tags shall be attached to all valves, including control valves, with nonferrous chain. Tags shall be brass and at least 1-1/2 inches in diameter. Nameplate and tag symbols shall correspond to the identification symbols on the temperature control submittal and the "as-built" drawings.
  19. Provide construction filters for all air handling units, fan coil unit, VAV boxes, and all other air handling equipment during the entire construction period.
  20. Provide temporary construction strainers for all strainers in the hydronic systems during the initial flushing of the systems.

### 3.3 CUTTING AND PATCHING

- A. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
- B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
  1. Uncover Work to provide for installation of ill-timed Work.
  2. Remove and replace defective Work.
  3. Remove and replace Work not conforming to requirements of the Contract Documents.
  4. Remove samples of installed Work as specified for testing.
  5. Install equipment and materials in existing structures.

6. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer/Owner's observation of concealed Work, without additional cost to the Owner.
  7. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers; refer to the materials and methods required for the surface and building components being patched; Refer to Paragraph 1.11 I for definition of "Installer."
- C. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including but not limited to removal of mechanical piping, mechanical ducts and HVAC units, and other mechanical items made obsolete by the new Work.
  - D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
  - E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

### 3.4 WORK SEQUENCE, TIMING, COORDINATION WITH OWNER, ARCHITECT AND ENGINEER

- A. The Owner will cooperate with the Contractor, however, the following provisions must be observed:
  1. A meeting will be held at the project site, prior to any construction, between the Owner's Representative, the General Contractor, the Sub-Contractors and the Engineer to discuss Contractor's employee parking space, access, storage of equipment or materials, and use of the Owner's facilities or utilities. The Owner's decisions regarding such matters shall be final.
  2. During the construction of this project, normal facility activities will continue in existing buildings until renovated areas are completed. Plumbing, fire protection, lighting, electrical, communications, heating, air conditioning, and ventilation systems shall be maintained in service within the occupied spaces of the existing building.
  3. Contractor shall not start-up any of the HVAC equipment unless the Owner, Architect and Engineer are signed off.
  4. Start-up for major HVAC equipment such as chillers, cooling towers, variable frequency drives and hot water boilers shall be performed by a factory technician. The start-up shall include a written report signed off by Contractor, Engineer and Owner.

### 3.5 DEMOLITION AND WORK WITHIN EXISTING BUILDINGS

- A. In the preparation of these documents every effort has been made to show the approximate locations of, and connections to, the existing piping, duct, equipment and other apparatus related to this phase of the Work. However, this Contractor shall be responsible for verifying all of the above information. This Contractor shall visit the existing site to inspect the facilities and related areas. This Contractor shall inspect and verify all details and requirements of all the Contract Documents, prior to the submission of a proposal. All discrepancies between the Contract Documents and actual job-site conditions shall be resolved by the contractor, who shall produce drawings that shall be submitted to the Architect/Engineer for review. All labor and materials required to perform the work described shall be a part of this Contract.

- B. All equipment and/or systems noted on the Drawings "To Remain" shall be inspected and tested on site to certify its working condition. A written report on the condition of all equipment to remain, including a copy of the test results and recommended remedial actions and costs shall be made by this Contractor to the Architect/Engineer for review.
- C. All equipment and/or systems noted on the Drawings "To Be Removed" shall be removed including, associated pipe and duct, pipe and duct hangers and/or line supports. Where duct or pipe is to be capped for future or end of line use, it shall be properly tagged with its function or service appropriately identified. Where existing equipment is to be removed or relocated and has an electric motor or connection, the Electrical Contractor shall disconnect motor or connection, remove wiring to a safe point and this Contractor shall remove or relocate motor or connection along with the equipment.
- D. During construction and remodeling, portions of the Project shall remain in service. Construction equipment, material, tools, extension cords, etc., shall be arranged so as to present minimum hazard or interruption to the occupants of the building. None of the construction work shall interfere with the proper operation of the existing facility; or be so conducted as to cause harm or danger to persons on the premises. All fire exits, stairs or corridors required for proper access, circulation or exit shall remain clear of equipment, materials or debris. The General Contractor shall maintain barricades, other separations in corridors and other spaces where work is conducted.
- E. Certain work during the demolition and construction phases may require overtime or night time shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner at least seventy-two (72) hours in advance in writing.
- F. Any salvageable equipment as determined by the Owner, shall be delivered to the Owner, and placed in storage at the location of his choice. All other debris shall be removed from the site immediately.
- G. Equipment, piping or other potential hazards to the occupants of the building shall not be left overnight outside of the designated working or construction area.
- H. Make every effort to minimize damage to the existing building and the Owner's property. Repair, patch or replace as required any damage that occurs as a result of work at the site. Care shall be taken to minimize interference with the Owner's activities during construction and to keep construction disrupted areas to a minimum. Coordinate with the Owner and other trades in scheduling and performance of the work.
- I. Include in the contract price all rerouting of existing pipe, duct, etc., and the reconnecting of the existing equipment as necessitated by field conditions to allow the installation of the new systems regardless of whether or not such rerouting, reconnecting or relocating is shown on the Drawings. Furnish all temporary pipe, duct, controls, etc., as required to maintain heating, cooling, and ventilation services for the existing areas with a minimum of interruption.
- J. All existing pipe, duct, materials, equipment, controls and appurtenances not included in the remodel or alteration areas are to remain in place.
- K. Pipe, duct, equipment and controls serving mechanical and other Owner's equipment, etc., which is to remain but is served by pipe, duct, equipment and controls that are disturbed by the remodeling work, shall be reconnected in such a manner as to leave this equipment in proper operating condition.
- L. No portion of the **fire protection systems** shall be turned off, modified or changed in any

way without the express knowledge and written permission of the Owner's representative in order to protect systems that shall remain in service.

- M. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and operating system in cooperation with other trades with a minimum of disruption or downtime.
- N. Refer to Architectural Demolition and/or Alteration plans for actual location of walls, ceilings, etc., being removed and/or remodeled.

**END OF SECTION**

## **SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**

### **PART 1 - GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 23 02 00, are included as a part of this Section as though written in full in this document.

#### **1.2 SCOPE**

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.
- B. **WORK SPECIFIED ELSEWHERE:**
  - 1. Painting
  - 2. Automatic temperature controls.
  - 3. Power control wiring to motors and equipment.

#### **1.3 WARRANTY**

Warrant the Work specified herein for one year and motors for five years beginning on the date of substantial completion.

#### **1.4 SUBMITTALS**

- A. **SHOP DRAWINGS:** Indicate size material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. **PRODUCT DATA:** Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures variations, and accessories.
- C. **MOTOR NAMEPLATE INFORMATION:** Manufacturer's name, address, utility and operating data.
- D. Refer to Division One for additional information.

#### **1.5 DELIVERY AND STORAGE**

- A. **DELIVERY:** Deliver clearly labeled, undamaged materials in the manufacturers' unopened containers.
- B. **TIME AND COORDINATION:** Deliver materials to allow for minimum storage time at the project site. Coordinate delivery with the scheduled time of installation.
- C. **STORAGE:** Store materials in a clean, dry location, protected from weather and abuse.

### **PART 2 - PRODUCTS**

## 2.1 ELECTRIC MOTORS

- A. APPROVED MANUFACTURERS: Provide motors by a single manufacturer as much as possible.
  - 1. Baldor
  - 2. Marathon
  - 3. Siemens-Allis
  - 4. General Electric
  - 5. U.S. Motor
- B. TEMPERATURE RATING: Provide insulation as follows:
  - 1. CLASS B: 40 degrees C maximum.
  - 2. CLASS F:
    - a. Between 40 degrees C and 65 degrees C maximum.
    - b. Totally enclosed motors.
- C. STARTING CAPABILITY: As required for service indicated five starts minimum per hour.
- D. PHASES AND CURRENT: Verify electrical service compatibility with motors to be used.
  - 1. UP TO 1/2 HP: Provide permanent split, capacitor-start single phase motors with inherent overload protection.
  - 2. 3/4 HP AND LARGER: Provide squirrel-cage induction polyphase motors.
  - 3. Provide two separate windings on 2-speed polyphase motors.
  - 4. Name plate voltage shall be the same as the circuit's normal voltage, serving the motor.
- E. SERVICE FACTOR: 1.15 for polyphase; 1.35 for single phase.
- F. FRAMES: U-frames 1.5 hp. and larger.
- G. BEARINGS: Provide sealed re-greaseable ball bearings; with top mounted zero lubrication fittings and bottom side drains minimum average life 100,000 hours typically, and others as follows:
  - 1. Design for thrust where applicable.
  - 2. PERMANENTLY SEALED: Where not accessible for greasing.
  - 3. SLEEVE-TYPE WITH OIL CUPS: Light duty fractional hp. motors or polyphase requiring minimum noise level.
- H. ENCLOSURE TYPE: Provide enclosures as follows:
  - 1. CONCEALED INDOOR: ODP (Open Drip Proof).
  - 2. EXPOSED INDOOR: Guard Protected.
  - 3. OUTDOOR TYPICAL: Type II. TEFC.
  - 4. OUTDOOR WEATHER PROTECTED: Type I. WPI.
  - 5. EXPLOSION PROOF, XP: For use in hazardous locations.
- I. OVERLOAD PROTECTION: Built-in sensing device for stopping motor in all phase legs and signaling where indicated for fractional horse power motors.
- J. NOISE RATING: "Quiet" except where otherwise indicated.

- K. EFFICIENCY: Minimum full load efficiency listed in the following table, when tested in accordance with IEEE Test Procedure 112A, Method B, including stray load loss measure.

Motor Horsepower	NEMA Efficiency INDEX Letter	Minimum Efficiency %
1800 RPM Synchronous Speed		
3-5	G	89.5
7.5	G	91.0
10	F	91.7
15-20	E	93.0
25-30	E	93.6
40	D	94.1
50	C	94.5
60	C	95.0
75	C	95.0
100-125	B	95.4
150-200	B	95.8
1200 RPM Synchronous Speed		
3-5	G	89.5
7.5	G	90.2
10	F	91.7
15	F	91.7
20	E	92.4
25-30	E	93.6
40-50	D	94.1
60	D	94.5
75	C	94.5
100-125	C	95.0
150-200	B	95.4

## 2.2 MOTOR CONTROLLERS (STARTERS)

- A. All motor controllers (for equipment furnished under Division 23) shall be furnished under Division 23 and installed under Division 26 unless otherwise noted on the plans.
1. Starters shall be provided for 3 phase motors 3/4 horsepower and greater.
- B. Motor starters shall be furnished as follows.
1. GENERAL: Motor starters shall be Square D Company Class 8536 across-the-line magnetic type, full-voltage, non-reversing (FAVOR) starter. All starters shall be constructed and tested in accordance with the latest NEMA standards, sizes and horsepower. ICE sizes are not acceptable. Starters shall be mounted in a general purpose dead front, painted steel enclosure and surface-mounted. Provide size and number of poles as shown and required by equipment served. Provide two speed, two winding or two speed, single winding motor starter as required for two speed motors.
  2. CONTACTS: Magnetic starter contacts shall be double break solid silver alloy. All contacts shall be replaceable without removing power wiring or removing starter from panel. The starter shall have straight-through wiring.
  3. OPERATING COILS: Operating coils shall be 120 volts and shall be of molded construction. When the coil fails, the starter shall open and shall not lock in the closed position.

4. OVERLOAD RELAYS: Provide manual reset, trip-free Class 20 overload relays in each phase conductor in of all starters. Overload relays shall be melting alloy type with visual trip indication. All 3 phase and single phase starters shall have one overload relay in each underground conductor. Relay shall not be field adjustable from manual to automatic reset. Provide 6 overload relays for two speed motor starters.
  5. PILOT LIGHTS: Provide a red running pilot light for all motor starters. Pilot lights shall be mounted in the starter enclosure cover. Pilot lights shall be operated from an interlock on the motor starter and shall not be wired across the operating coil.
  6. CONTROLS: Provide starters with HAND-OFF-AUTOMATIC switches. Coordinate additional motor starter controls with the requirements of Division 23. Motor starter controls shall be mounted in the starter enclosure cover.
  7. CONTROL POWER TRANSFORMER: Provide a single-phase 480 volt control power transformer with each starter for 120 volt control power. Connect the primary side to the line side of the motor starter. The primary side shall be protected by a fuse for each conductor. The secondary side shall have one leg fused and one leg grounded. Arrange transformer terminals so that wiring to terminals will not be located above the transformer.
  8. AUXILIARY CONTACTS: Each starter shall have one normally open and one normally closed convertible auxiliary contact in addition to the number of contacts required for the "holding interlock", remote monitoring, and control wiring. In addition, it shall be possible to field-install three more additional auxiliary contacts without removing existing wiring or removing the starter from its enclosure.
  9. UNIT WIRING: Unit shall be completely pre-wired to terminals to eliminate any interior field wiring except for line and load power wiring and HVAC control wiring.
  10. ENCLOSURES: All motor starter enclosures shall be NEMA 1, general purpose enclosures or NEMA-3R if mounted exposed to high moisture conditions. Provide NEMA 4X when located by cooling towers.
  11. POWER MONITOR: Provide a square "D" 8430 MPS phase failure and under-voltage relay, base and wiring required for starters serving all 3 phase motors. Set the under-voltage setting according to minimum voltage required for the motor to operate within its range.
- C. APPROVED MANUFACTURERS: Controller numbers are based on first named manufacturer. Provide one of the following manufacturer's.
1. Siemens.
  2. Square D.
  3. General Electric.
  4. Eaton.

### 2.3 COMBINATION MOTOR STARTERS

- A. GENERAL: Combination motor starters shall consist of a magnetic starter and a fusible or non-fusible disconnect switch in a dead front, painted steel NEMA 1 enclosure unless otherwise noted and shall be surface-mounted. Size and number of poles shall as shown and required by equipment served. Combination motor starters shall be as specified for motor starters in Paragraph 2.1/B, except as modified herein.
- B. DISCONNECT SWITCH: Disconnect switches shall be as specified in Section 26 28 16.
- C. APPROVED MANUFACTURERS: Controller numbers are based on first named manufacturer. Provide one of the following manufacturer's.

1. Siemens.
2. Square D.
3. General Electric.

### PART 3 - EXECUTION

- 3.1 All equipment shall be installed in accordance with the manufacturers' recommendations and printed installation instructions.
- 3.2 All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Contractors' price shall include all items required as per manufacturers' requirements.
- 3.3 INSTALLATION
- A. GENERAL: Install in a professional manner. Any part or parts not meeting this requirement shall be replaced or rebuilt without extra expense to Owner.
  - B. Install rotating equipment in static and dynamic balance.
  - C. Provide foundations, supports, and isolators properly adjusted to allow minimum vibration transmission within the building.
  - D. Correct objectionable noise or vibration transmission in order to operate equipment satisfactorily as determined by the Engineer.

**END OF SECTION**

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## **SECTION 23 05 26 - VARIABLE FREQUENCY MOTOR SPEED CONTROL FOR HVAC EQUIPMENT**

### **PART 1 - GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. Section 1.1 A in Section 23 05 13
- B. Section 1.1 B in Section 23 05 13
- C. Furnish and install a complete adjustable frequency motor speed control for the following items:
  - 1. Variable volume air handling units.
  - 2. Chilled water pumps
  - 3. Condenser water pumps
  - 4. Hot water pumps
  - 5. Cooling tower fans.
  - 6. Variable volume ventilation fans.

#### **1.2 RELATED SECTIONS**

- A. Section 23 02 00 – Basic Materials and Methods
- B. Section 23 05 13 – Common Motor Requirements for HVAC Equipment
- C. Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment
- D. Section 23 05 93 – Testing, Adjusting and Balancing

#### **1.3 SUBMITTALS**

- A. Submit shop drawings and product data under provisions of Division One.
- B. Certified noise data shall be submitted by drive manufacturer. Noise generated by variable frequency motor speed control drive shall not exceed preferred “RC” as listed in 2015 ASHRAE HVAC Applications, Chapter 48 Noise and Vibration Control, Table 2 Criteria for Acceptable HVAC Noise in Unoccupied Rooms.

#### **1.4 WARRANTY**

- A. Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. The warranty shall include all parts, labor, travel time and expenses. There shall be 365/24 support available via a toll-free phone number.

#### **1.5 DELIVERY, STORAGE AND HANDLING**

- A. Equipment shall be stored and handled per manufacturer’s instructions.

#### **1.6 OPERATIONS PERSONNEL TRAINING**

- A. Provide a training session for the owner’s operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:

1. Purpose of equipment.
2. Principle of how the equipment works.
3. Important parts and assemblies.
4. How the equipment achieves its purpose and necessary operating conditions.
5. Most likely failure modes, causes and corrections.
6. On site demonstration.

## PART 2 - PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- A. Yaskawa/Magnetek
- B. ABB
- C. Danfoss

### 2.2 ADJUSTABLE FREQUENCY INVERTER

- A. The AFD package as specified herein shall be enclosed in a NEMA 12 enclosure for interior applications, a NEMA 3R enclosure for exterior locations and a NEMA 4X enclosure where located in a cooling tower yard or within 20 feet from cooling tower. All enclosures shall be completely assembled and tested by the manufacturer in an ISO9001 facility. The AFD shall operate from a line of +30% over nominal and the under-voltage trip level shall be 35% under the nominal voltage as a minimum.
- B. The fused input shall utilize fast acting current limiting type per manufacturer recommendations.
- C. The variable frequency power and logic unit shall be completely solid state. The unit shall transform 480 Volt or 208 Volt (as indicated on plans), 3 phase, 60 hertz input power into frequency and voltage controlled, 3 phase output power suitable to provide positive speed and torque control to the fan motor. The speed control shall be step-less throughout the speed range under variable torque load on a continuous basis. The adjustable frequency control shall be of a pulse width modulated type utilizing a full wave diode bridge rectifier; and shall have a power factor of 0.95 or better at all motor loads.
- D. All AFD's shall have the same customer interface, including a backlit LCD two-line digital display, and keypad, regardless of horsepower rating. The keypad is to be used for local control, for setting all parameters, and for stepping through the displays and menus. The keypad shall be removable, capable of remote mounting, and shall have its own non-volatile memory. The keypad shall allow for uploading and downloading of parameter settings as an aid for the start-up of multiple AFD's. The keypad shall include Hand-Off-Auto membrane selections. When in "Hand", the AFD will be started and the speed will be controlled from the up/down arrows. When in "Off", the AFD will be stopped. When in "Auto", the AFD will start via an external contact closure and the AFD speed will be controlled via an external speed reference.
- E. The adjustable frequency inverter shall conduct no radio frequency interference (RFI) back to the input power line.
- F. The AFD shall have an integral 5% impedance line reactor to reduce the harmonics to the power line and to add protection from AC line transients. The inverter/reactor shall be a single wiring point.

## 2.3 SELF PROTECTION

- A. The following features for self-protection shall be included:
1. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes. The minimum FLA rating shall meet or exceed the values in the NEC/UL Table 430-150 for 4-pole motors.
  2. Limit the output current in under 50 microseconds due to phase to phase short circuits or severe overload conditions.
  3. Protect the inverter due to non-momentary power or phase loss. The undervoltage trip shall activate automatically when the line voltage drops 15% below rated input voltage.
  4. Protect the inverter due to voltage levels in excess of its rating. The overvoltage trip shall activate automatically when the DC bus in the controller exceeds 1000 VDC.
  5. Protect the inverter from elevated temperatures in excess of its rating. An indicating light that begins flashing within 10 degrees C of the trip shall be provided to alert the operator to the increasing temperature condition. When the over temperature trip point is reached, this light shall be continuously illuminated.
  6. The inverter shall be equipped such that a trip condition resulting from overcurrent, undervoltage, overvoltage or overtemperature shall be automatically reset, and the inverter shall be automatically reset, and the inverter shall automatically restart upon removal, or correction of the faulty condition.
  7. Status lights for indication of conditions described above shall be provided. A SPDT contact for remote indication shall be provided. Additionally, status lights to show power on, zero speed, and drive enabled shall be provided. All status lights shall be self-contained in the front panel of the unit and shall be duplicated for ease of troubleshooting on the inside of the unit.
  8. Current and voltage signals shall be isolated from logic circuitry.
  9. Drive logic shall be microprocessor based.
  10. In the event of a sustained power loss, the control shall shut down safely without component failure. Upon return of power, the system shall automatically return to normal operation if the start is in the "On" condition.
  11. In the event of a momentary power loss, the control shall be shut down safely without component failure. Upon return of power, the system shall automatically return to normal operation (if the start is in the "On" position) being able to restart into a rotating motor regaining positive speed control without shutdown or component failure.
  12. In the event of a phase to phase short circuit, the control shall shut down safely without component failure.
  13. In the event that an input power contactor is opened or closed while the control is activated, no damage shall result.
  14. To facilitate startup and troubleshooting, the control shall operate without a motor or any other equipment connected to the inverter output.

## 2.4 ELECTRICAL CONSTANT SPEED BYPASS

- A. Provide all components and circuitry necessary to provide manual full bypass of the inverter. The bypass package shall be mounted in a cabinet common with the inverter and shall be constructed in such a manner that the inverter can be removed for repair while still operating the motor in the "bypass" mode. Fast-acting semi-conductor with a fuse block shall be provided to isolate the drive for service. Bypass designs that have no such fuses must have a lockable disconnect that isolates the drive while running in bypass mode. The Contractor device shall be NEC approved. A common start/stop signal shall be used for both the variable frequency drive mode and bypass mode. Manual bypass shall contain the following:

1. Two contactors mechanically interlocked via a three position through the door selector switch or keypad to provide the following controls:
  - a. "Inverter" mode connects the motor to the output of the inverter.
  - b. "Bypass" mode connects the motor to the input since wave power. Transfer must occur with input disconnect open. Motor is protected via electronic overload.
  - c. "Off" mode disconnects motor from all input power.
  - d. A molded case circuit breaker with door interlocked handle (lock out type) that interrupts input power to both the bypass circuitry and the drive.
  - e. Customer Interlock Terminal Strip – provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is Hand, Auto, or Bypass mode. The remote start/stop contact shall operate in AFD and bypass modes.
  - f. An electronic overload selectable for class 20 or 30 shall provide protection of the motor in Bypass mode.
  
2. The following indicating lights (LED type) shall be provided. A test mode or push to test feature shall be provided.
  - a. Power on
  - b. External fault
  - c. Drive mode selected
  - d. Bypass mode selected
  - e. Drive running
  - f. Bypass running
  - g. Drive fault
  - h. Bypass fault
  - i. Bypass-H-O-A mode
  - j. Automatic transfer to bypass selected
  
3. The following relay (form C) outputs from the bypass shall be provided:
  - a. System started
  - b. System running
  - c. Bypass override enabled
  - d. Drive fault
  - e. Bypass fault (motor overload or underload (broken belt))
  - f. Bypass H-O-A position
  
4. The AFD shall include a "run permissive circuit" that will provide a normally open contact any time a run command is provided (local or remote start command in AFD or bypass mode). The AFD system (AFD or bypass) shall not operate the motor until it receives a dry contact closure from a damper or valve end-switch). When the AFD systems safety interlock (fire detector, freezestat, high static pressure switch, etc.) opens, the motor shall coast to a stop and the run permissive contact shall open, closing the damper or valve.
5. There shall be an internal switch to select manual or automatic bypass.
6. There shall be an adjustable current sensing circuit for the bypass to provide loss of load indication when in the bypass mode.
7. The bypass mode must include an undervoltage and phase loss relay to protect the motor from single phase power and undervoltage conditions.
  - a. Bypass shall be UL listed.
  - b. Bypass shall carry a UL 508 label.

## 2.5 FEATURES AND SPECIFICATIONS

- A. Output frequency shall neither vary with load nor with any input frequency variations. Output frequency shall not vary within +/-10% input voltage changes. Output frequency shall not vary with temperature changes within the ambient specification.
- B. No auxiliary equipment shall be required. The output frequency shall be adjusted in proportion to 4-20 mA signal.
- C. A 0 to 10 Volt DC signal shall be provided for remote indication. This 0 to 10 Volt DC signal shall vary in direct proportion to the controller speed.
- D. The controller shall be started or stopped by a contact closure or through serial communications.
- E. A single pole, double throw contact shall be provided for remote indication. Contact will change state when any trip condition has occurred. (contact rated for 12-250 VAC-24 AMPS).
- F. A second single pole, double throw contact shall be provided for remote indication. Contact will state when the VFD receives a run command (contact rated for 12-250 VAC-24 AMPS).
- G. PID Setpoint controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the AFD, using the microprocessor in the AFD for the closed loop control. The AFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID setpoint shall be adjustable from the AFD keypad, analog inputs, or over the communications bus.
- H. Unit to operate from a 4 to 20 mA input signal and shall have hand-off-auto switch and door mounted potentiometer controls for manual speed selection.
- I. Acceleration and deceleration times shall be adjustable from 30 to 300 seconds.
- J. The drive shall have the ability to invert the speed signal input, as well as having offset and gain controls for speed signal conditioning.
- K. Minimum and maximum speeds shall be adjustable in automatic and manual modes.
- L. Hazard inputs shall be provided, capable of up to two inputs (fire, freeze). These shall each be capable of safely shutting down the inverter and illuminating a front panel hazard light depicting that a hazard condition turned the inverter off.
- M. The inverter shall be a starter, containing a door interlocked input disconnect switch and manual reset motor electronic overloads, with accessible reset on front door, when a bypass is not specified.
- N. Solid state ground fault interrupt circuit.
- O. The LED display shall monitor and display four parameters on a single display (i.e. frequency command, output frequency, output current, and torque).
- P. A N.O. auxiliary run-time contact shall be provided for control signaling to auxiliary equipment. Contact shall close when the pump is brought on line and open when the pump is taken off line. Contact shall be rated 20 amps at 120 volts.

- Q. Inverter shall be UL listed.
- R. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the Owner, and a copy kept on file at the manufacturer
- S. Factory trained application engineering and service personnel that are thoroughly familiar with the AFD products offered shall be locally available at both the specifying and installation locations. A 24/365 technical support line shall be available on a toll-free line.
- T. A computer based training CD or 8-hour professionally generated video (VCR format) shall be provided to the Owner at the time of Substantial Completion. The training shall include installation, programming and operation of the AFD, bypass and serial communication.
- U. Provide a motor end surge control voltage suppressive filter if the VFD manufacturer cannot limit their voltage surges to under 1000 volt at 100 feet.
- V. Provide a motor acoustic noise reduction filter capable of approximately 12 dBA attenuation, if the VFD raises the dBa level above 3 dBa at a distance of 3 feet from the motor.
- W. Provide each unit with a 3% reactor which is mounted on both the positive and negative DC bus. The reactor shall be a single wiring point and mounted internally to the drive.
- X. Adjustable frequency inverters shall have native BACnet protocol for integration with EMCS. If the in inverter does not have native BACnet protocol, a BACnet interface card shall be provided.

### PART 3 - INSTALLATION

- 3.1 Install units in accordance with manufacturer's published installation instructions. Variable frequency speed control shall be located so that wiring to motor does not exceed 100 feet.

### END OF SECTION

## **SECTION 23 05 29 – HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT - HVAC**

### **PART 1 - GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods is included as a part of this Section as though written in full in this document.

#### **1.2 WORK INCLUDED**

- A. Pipe, and equipment hangers, supports and associated anchors.
- B. Sleeves and seals.
- C. Flashing and sealing equipment and pipe stacks.

#### **1.3 RELATED WORK**

- A. Section 21 00 00 – Fire Suppression.
- B. Section 22 10 00 – Plumbing Piping and Pumps.
- C. Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment.
- D. Section 23 07 16 – HVAC Equipment Insulation.
- E. Section 23 07 19 – HVAC Piping Insulation.

#### **1.4 REFERENCES**

- A. ANSI/ASME B31.1 - Power Piping.
- B. NFPA 13 - Standard for the Installation of Sprinkler Systems.
- C. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems.

#### **1.5 QUALITY ASSURANCE**

- A. Supports for Sprinkler Piping: In conformance with NFPA 13.
- B. Supports for Standpipes: In conformance with NFPA 14.

#### **1.6 SUBMITTALS**

- A. Submit shop drawings and product data under provisions of Division One.
- B. Indicate hanger and support framing and attachment methods.

### **PART 2 - PRODUCTS**

#### **2.1 PIPE HANGERS AND SUPPORTS**

- A. Hangers for Pipes Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.
- B. Hangers for Pipes Sizes 2 to 4 Inch: Carbon steel, adjustable clevis.
- C. Hangers for Pipes Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roller, double hanger.
- D. Multiple or Trapeze Hangers: Steel channels with welded spacers, pre-formed manufactured saddles and hanger rods; cast iron roller and stand for pipe sizes 6 inches and over.
- E. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
- F. Wall Support for Pipe Sizes 4 Inches and over: adjustable steel yoke and cast iron roller.
- G. Vertical Support: Steel riser clamp.
- H. Floor Support for Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.
- I. Floor Support for Pipe Sizes 6 Inches and Over: Adjustable cast iron roller and stand, steel screws, and concrete pier or steel support.
- J. Roof Pipe Supports and Hangers: Galvanized Steel Channel System as manufactured by Portable Pipe Hangers, Inc. or approved equal.
  - 1. For pipes 2-1/2" and smaller – Type PP10 with roller
  - 2. For pipes 3" through 8" – Type PS
  - 3. For multiple pipes – Type PSE - Custom
- K. Copper Pipe Support and Hangers: Electro-galvanized with thermoplastic elastomer cushions; Unistrut "Cush-A-Clamp" or equal. Hangers: Plastic coated; Unistrut or equal.
- L. Shields for Vertical Copper Pipe Risers: Sheet lead.
- M. Pipe Rough-In Supports in Walls/Chases: Provide preformed plastic pipe supports, Sioux Chief "Pipe Titan" or equal.

## 2.2 HANGER RODS

- A. Galvanized Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.

## 2.3 INSERTS

- A. Inserts: Malleable iron case with galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

## 2.4 FLASHING

- A. Metal Flashing: 20 gage galvanized steel.
- B. Lead Flashing: 4 lb. /sq. ft. sheet lead for waterproofing; 1 lb. /sq. ft. sheet lead for soundproofing.

- C. Caps: Steel, 20 gage minimum; 16 gage at fire resistant elements.
- D. Coordinate with roofing contractor/Architect for type of flashing on metal roofs.

## 2.5 EQUIPMENT CURBS

- A. Fabricate curbs of hot dipped galvanized steel.
- B. For metal roof construction, roof curbs shall be made of aluminum or stainless steel. Coordinate with Architectural Drawings and details.

## 2.6 SLEEVES

- A. Sleeves for Pipes through Non-fire Rated Floors: Form with 18 gage galvanized steel, tack welded to form a uniform sleeve.
- B. Sleeves for Pipes through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Form with steel pipe, Schedule 40.
- C. Sleeves for Pipes through Fire Rated and Fire Resistive Floors and Walls, and Fireproofing: Prefabricated fire rated steel sleeves including seals, UL listed.
- D. Sleeves for Round Ductwork: Form with galvanized steel.
- E. Sleeves for Rectangular Ductwork: Form with galvanized steel.
- F. Fire Stopping Insulation: Glass fiber type, non-combustible, U.L. listed.
- G. Caulk: Paintable 25-year acrylic sealant.
- H. Pipe Alignment Guides: Factory fabricated, of cast semi-steel or heavy fabricated steel, consisting of bolted, two-section outer cylinder and base with two-section guiding spider that bolts tightly to pipe. Length of guides shall be as recommended by manufacturer to allow indicated travel.

## 2.7 FABRICATION

- A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- B. Design hangers without disengagement of supported pipe.
- C. Design roof supports without roof penetrations, flashing or damage to the roofing material.

## 2.8 FINISH

- A. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

## PART 3 - EXECUTION

### 3.1 INSERTS

- A. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams. Coordinate with Structural Engineer for placement of inserts.

- B. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
- C. Where concrete slabs form finished ceiling, provide inserts to be flush with slab surface.
- D. Where inserts are omitted, drill through concrete slab from below and provide thru-bolt with recessed square steel plate and nut recessed into and grouted flush with slab. Verify with Structural Engineer prior to start of work.

### 3.2 PIPE HANGERS AND SUPPORTS

- A. Support horizontal piping as follows:

<u>PIPE SIZE</u>	<u>MAX. HANGER SPACING</u>	<u>HANGER DIAMETER</u>
(Steel Pipe)		
1/2 to 1-1/4 inch	7'-0"	3/8"
1-1/2 to 3 inch	10'-0"	3/8"
4 to 6 inch	10'-0"	1/2"
8 to 10 inch	10'-0"	5/8"
12 to 14 inch	10'-0"	3/4"
15 inch and over	10'-0"	7/8"
(Copper Pipe)		
1/2 to 1-1/4 inch	5'-0"	3/8"
1-1/2 to 2-1/2 inch	8'-0"	3/8"
3 to 4 inch	10'-0"	3/8"
6 to 8 inch	10'-0"	1/2"
(Cast Iron)		
2 to 3 inch	5'-0"	3/8"
4 to 6 inch	10'-0"	1/2"
8 to 10 inch	10'-0"	5/8"
12 to 14 inch	10'-0"	3/4"
15 inch and over	10'-0"	7/8"
(PVC Pipe)		
1-1/2 to 4 inch	4'-0"	3/8"
6 to 8 inch	4'-0"	1/2"
10 and over	4'-0"	5/8"

- B. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent

work.

- C. Place a hanger within 12 inches of each horizontal elbow, and at the vertical to horizontal transition.
- D. Use hangers with 1-1/2 inch minimum vertical adjustment.
- E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
- F. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
- G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- H. Support riser piping independently of connected horizontal piping.
- I. Install hangers with nut at base and above hanger; tighten upper nut to hanger after final installation adjustments.
- J. Portable pipe hanger systems shall be installed per manufacturer's instructions.
- K. Distances between supports are maximum distance. Supports shall be provided to carry the pipe/equipment load.

3.3 INSULATED PIPING: Comply with the following installation requirements.

- A. Clamps: Attach galvanized clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9.
- B. Saddles: Install galvanized protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation. Secure the full contact area of the saddle to the pipe insulation with 1/8" thick coat of mastic.
- C. Shields: Install protective shields MSS Type 40 on cold and chilled water piping that has vapor barrier. Secure the full contact area of the shield to the pipe insulation with 1/8" thick coat of mastic.
- D. Shields shall span an arc of 180 degrees and shall have dimensions in inches not less than the following:

NPS	LENGTH	THICKNESS
1/4 THROUGH 3-1/2	12	0.048
4	12	0.060
5 & 6	18	0.060
8 THROUGH 14	24	0.075
16 THROUGH 24	24	0.105

- E. Piping 2" and larger: provide galvanized sheet metal shields with calcium silicate insulation at hangers/supports.
- F. Insert material shall be at least as long as the protective shield.
- G. Thermal Hanger Shields: Install where indicated, with insulation of same thickness as piping.

### 3.4 EQUIPMENT BASES AND SUPPORTS

- A. Provide equipment bases of concrete.
- B. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.
- C. Construct support of steel members. Brace and fasten with flanges bolted to structure.
- D. Provide rigid anchors for pipes after vibration isolation components are installed.

### 3.5 FLASHING

- A. Provide flexible flashing and metal counter flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
- B. Flash vent and soil pipes projecting 8 inches minimum above finished roof surface with lead worked one inch minimum into hub, 8 inches minimum clear on sides with 24 x 24 inches sheet size. For pipes through outside walls, turn flanges back into wall and caulk. Provide metal counter flash and seal.
- C. Flash floor drains in floors with topping over finished areas with lead, 10 inches clear on sides with minimum 36 x 36 inch sheet size. Fasten flashing to drain clamp device.
- D. Seal floor, shower, mop sink, and all other drains watertight to adjacent materials.
- E. Provide curbs for mechanical roof installations 8 inches minimum high above roofing surface. Contact Architect for all flashing details and roof construction. Seal penetrations watertight.

### 3.6 SLEEVES

- A. Set sleeves in position in formwork. Provide reinforcing around sleeves.
- B. Extend sleeves through floors minimum one inch above finished floor level. Caulk sleeves full depth with fire rated thermafiber and 3M caulking and provide floor plate.
- C. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with U.L. listed fire stopping insulation and caulk seal air tight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
- D. Fire protection sleeves may be flush with floor of stairways.

### END OF SECTION

## **SECTION 23 05 48 – VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT**

### **PART 1 - GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. This Section and Section 23 02 00 – Basic Materials and Methods are part of each Division 23 Section which references the vibration control products specified herein.

#### **1.2 WORK INCLUDED**

- A. Vibration and sound control products.

#### **1.3 QUALITY ASSURANCE**

- A. **Manufacturer's Qualifications:** Firms regularly engaged in manufacture of vibration control products of type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Vibration and sound control products shall conform to ASHRAE criteria for average noise criteria curves for all equipment at full load conditions.
- C. Unless otherwise indicated, sound and vibration control products shall be provided by a single manufacturer.

#### **1.4 SUBMITTALS**

- A. **SHOP DRAWINGS:** Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. **PRODUCT DATA:** Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, product variations, and accessories.

### **PART 2 - PRODUCTS**

#### **2.1 ACCEPTABLE MANUFACTURERS**

- A. Amber/Booth Company, Inc.
- B. Mason Industries, Inc.
- C. Kinetics Noise Control, Inc.

#### **2.2 GENERAL**

- A. Provide vibration isolation supports for equipment, piping and ductwork, to prevent transmission of vibration and noise to the building structure that may cause discomfort to the occupants.
- B. Model numbers of Amber/Booth products are included for identification. Products of the additional manufacturers will be acceptable provided they comply with all the requirements of this specification.

### 2.3 FLOOR MOUNTED AIR HANDLING UNITS

- A. Provide Amber/Booth CAL-2 aluminum housed isolators sized for 2" static deflection. Cast iron or steel housings may be used provided they are hot-dip galvanized after fabrication
- B. If floor mounted air handling units are furnished with internal vibration isolation option, provide 2" thick Amber/Booth NRC ribbed neoprene pads to address high frequency breakout and afford additional unit elevation for condensate drains. Ribbed neoprene pads shall be located in accordance with the air handling unit manufacturer's recommendations.

### 2.4 SUSPENDED AIR HANDLING UNITS

- A. Provide Amber/Booth HRS-2 combination spring and rubber-in-shear isolation hanger sized for 2" static deflection.
- B. If suspended air handling units are furnished with internal vibration isolation option, furnish Amber/Booth HR rubber-in-shear isolation hangers sized for approximately ½" deflection to address high frequency break-out.

### 2.5 SUSPENDED FANS AND FAN COIL UNITS

- A. Provide Amber/Booth HS spring hangers sized for 1" static deflection.

### 2.6 BASE MOUNTED PUMPS

- A. Provide Amber/Booth SP-NR style E flexplate pad isolators consisting of two layers of 3/8" thick alternate ribbed neoprene pad bonded to a 16 gage galvanized steel separator plate.
- B. Pads shall be sized for approximately 40 PSI loading and 1/8" deflection.
- C. Provide Amber/Booth CPF, 8" concrete inertia base. Base shall be welded steel construction with concrete in-fill supplied by the contractor on site and shall incorporate standard rebar reinforcement, spaced a maximum of 12" on center. Provide Amber/Booth AWH, floor mounted spring isolators sized for 1" static deflection.
- D. Provide inertia bases for all base mounted pump applications in which the pumps are to be installed on any floor level other than the ground floor or grade level. Inertia bases shall also be provided for base mounted pump applications in which the associated mechanical room where they are housed is in a noise sensitive location, regardless of floor level.

### 2.7 BASE MOUNTED CHILLERS

- A. Amber/Booth SP-NR style E flexplate pad isolators consisting of two layers of 3/8" thick alternate ribbed neoprene pad bonded to a 16 gage galvanized steel separator plate.
- B. Pads shall be sized for approximately 40 PSI loading and 1/8" deflection.

### 2.8 ROOF MOUNTED COOLING TOWERS

- A. Provide Amber/Booth M series steel housed spring isolators with vertical uplift restraints sized for 3" static deflection.

- B. Isolators to have weatherproof construction with cadmium plated springs, hot-dip galvanized housings, and zinc-electroplated hardware. Removable spring packages to include ¼" ribbed neoprene pad under baseplate(s).
- C. Steel beams between the top of the isolators and bottom of cooling tower cells shall be provided and coordinated with the structural engineer.

## 2.9 PIPING

- A. Provide spring and rubber-in-shear hangers, Amber/Booth HRS in mechanical equipment rooms, for a minimum distance of 50 feet from isolated equipment for all chilled water and hot water piping 1-1/2" diameter and larger. Springs shall be sized for 1" deflection.
- B. Floor supported piping is required to be isolated with Amber/Booth AW-1 open springs sized for 1" deflection.
- C. All condenser water piping shall be supported with Amber/Booth AW-1 with 1" deflection for floor or roof mounted piping and Amber/Booth HRS isolators with 1" deflectors for suspended piping.
- D. Furnish line size flexible connectors at supply and return of pumps, Amber/Booth style 2800 single sphere EPDM construction, connector shall include 150 lb. cadmium plated carbon steel floating flanges.

## 2.09 CORROSION PROTECTION

- A. All vibration isolators shall be designed and treated for resistance to corrosion.
- B. Steel components: PVC coated or phosphate coated and painted with industrial grade enamel. Nuts, bolts, and washers: zinc-electroplated.

## PART 3 - EXECUTION

- 3.1 All equipment shall be installed in accordance with the manufacturer's recommendations and printed installation instructions.
- 3.2 All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.
- 3.3 If internal isolation option is used on air handling units, the mechanical contractor shall verify proper adjustment and operation of isolators prior to start-up. All shipping brackets and temporary restraint devices shall be removed.
- 3.4 The vibration isolation supplier shall certify in writing that he has inspected the installation and that all external isolation materials and devices are installed correctly and functioning properly.

**END OF SECTION**

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## **SECTION 23 05 53 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT**

### **PART 1 - GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 – Basic Materials and Methods is included as a part of this Section as though written in full in this document.

#### **1.2 SCOPE**

Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.

- 1.3 Refer to Architectural Sections for additional requirements.

### **PART 2 - PRODUCTS**

#### **2.1 VALVE AND PIPE IDENTIFICATION**

##### **A. Valves:**

- 1. All valves shall be identified with a 1-1/2" diameter brass disc wired onto the handle. The disc shall be stamped with 1/2" high depressed black filled identifying numbers. These numbers shall be numerically sequenced for all valves on the job.
- 2. The number and description indicating make, size, model number and service of each valve shall be listed in proper operational sequence, properly typewritten. Three copies to be turned over to Owner at completion.
- 3. Tags shall be fastened with approved meter seal and 4 ply 0.018 smooth copper wire. Tags and fastenings shall be manufactured by the Seton Name Plate Company or approved equal.
- 4. All valves shall be numbered serially with all valves of any one system and/or trade grouped together.

##### **B. Pipe Marking:**

- 1. All interior visible piping located in accessible spaces such as above accessible ceilings, equipment rooms, attic space, under floor spaces, etc., shall be identified with all temperature pipe markers as manufactured by W.H. Brady Company, 431 West Rock Ave., New Haven, Connecticut, or approved equal.
- 2. All exterior visible piping shall be identified with UV and acid resistant outdoor grade acrylic plastic markers as manufactured by Set Mark distributed by Seton (Name plate Company Factory location 20 Thompson Road, Branford, Connecticut) or approved equal.
- 3. Generally, markers shall be located on each side of each and every partition, on each side of every tee, on each side of every valve and/or valve group, on each side of every piece of equipment, and, for straight runs, at equally spaced intervals not to exceed 75 feet. In congested area, marks shall be placed on each pipe at the points where it enters and leaves the area and at the point of connection of each piece of equipment and automatic control valve. All markers shall have directional arrows.
- 4. Markers shall be installed after final painting of all piping and equipment and in

such a manner that they are visible from the normal maintenance position. Manufacturer's installation instructions shall be closely followed.

5. Markers shall be colored as indicated below per ANSI/OSHA Standards:

<u>SYSTEM</u>	<u>COLOR</u>	<u>LEGEND</u>
Chilled Water	Green	Chilled Water Supply Chilled Water Return
Hot Water	Reddish Orange	Hot Water Supply Return
Condenser Water	Green	Condenser Water Supply Condenser Water Return
Compressed Air	Blue	Compressed Air
Pneumatic Control	Yellow	Pneumatic Controls
Oxygen	Yellow	Oxygen
Nitrogen	Green	Nitrogen
Deionized Water	Green	Deionized Water
Steam	Yellow	Steam Supply Steam Return

C. Pipe Painting:

1. All piping exposed to view shall be painted as indicated or as directed by the Architect in the field. Confirm all color selections with Architect prior to installation.
2. All piping located in mechanical rooms and exterior piping shall be painted as indicated below:

<u>System</u>	<u>Color</u>
Condenser Water Supply and Return	Light Green
Chilled Water Supply and Return	Light Blue
Heating Hot Water Supply and Return	Reddish Orange

## 2.2 EQUIPMENT IDENTIFICATION

- A. Mechanical equipment shall be identified by means of nameplates permanently attached to the equipment. Nameplates shall be engraved laminated plastic or etched metal. Submittals shall include dimensions and lettering format for approval. Attachment shall be with escutcheon pins, self-tapping screws, or machine screws.

## PART 3 - EXECUTION

- 3.1 All labeling equipment shall be installed as per manufacturer's printed installation instructions.
- 3.2 All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Contractors price shall include all items required as per manufacturer's requirements.
- 3.3 All piping shall be cleaned of rust, dirt, oil and all other contaminants prior to painting. Refer to

Division 9 for Architect's required paint system(s).

**END OF SECTION**

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## **SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING**

### **PART 1 - GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 – Basic Materials and Methods is included as a part of this Section as though written in full in this document.

#### **1.2 RELATED DOCUMENTS**

Approved submittal date on equipment installed, to accomplish the test procedures, outlined under paragraph 3.1 of this Section, will be provided by the Contractor.

#### **1.3 DESCRIPTION**

- A. The TAB of the air conditioning systems shall be performed by an impartial technical firm hired by Owner whose operations are limited only to the field of professional TAB. The TAB work will be done under the direct supervision of a qualified engineer employed by the TAB firm.
- B. The TAB firm will be responsible for inspecting, adjusting, balancing, and logging the data on the performance of fans, dampers in the duct system, and air distribution devices. The Contractor and the various Subcontractors of the equipment installed shall cooperate with the TAB firm to furnish necessary data on the design and proper applications of the system components and provide labor and material required to eliminate deficiencies or malperformance.

#### **1.4 QUALITY ASSURANCE**

- A. **QUALIFICATIONS OF CONTRACTOR PERSONNEL:** Submit evidence to show that the personnel who shall be in charge of correcting deficiencies for balancing the systems are qualified. The Owner and Engineer reserve the right to require that the originally approved personnel be replaced with other qualified personnel if, in the Owner and Engineer's opinion, the original personnel are not qualified to properly place the system in condition for balancing.
- B. **QUALIFICATIONS OF TAB FIRM PERSONNEL:**
  - 1. A minimum of one registered Professional Engineer licensed in the State, is required to be in permanent employment of the firm.
  - 2. Personnel used on the jobsite shall be either Professional Engineers or technicians, who shall have been permanent, full time employees of the firm for a minimum of six months prior to the start of Work for that specified project.
  - 3. Evidence shall be submitted to show that the personnel who actually balance the systems are qualified. Evidence showing that the personnel have passed the tests required by the Associated Air Balance Council (AABC) shall be required.
- C. **CALIBRATION LIST:** Submit to the Engineer for approval, a list of the gauges, thermometers, velometer, and other balancing devices to be used in balancing the system. Submit evidence to show that the balancing devices are properly calibrated before proceeding with system balancing.

### 1.5 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
1. Purpose of equipment.
  2. Principle of how the equipment works.
  3. Important parts and assemblies.
  4. How the equipment achieves its purpose and necessary operating conditions.
  5. Most likely failure modes, causes and corrections.
  6. On site demonstration.

### PART 2 - PRODUCTS (NOT USED)

### PART 3 - EXECUTION

#### 3.1 SERVICES OF THE CONTRACTOR

- A. The Drawings and Specifications have indicated valves, dampers, and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions. Install these devices in a manner that leaves them accessible, and provide access as requested by the TAB firm.
- B. Have systems complete and in operational readiness prior to notifying the TAB firm that the project is ready for their services, and certify in writing to the Architect and Owner that such a condition exists.
- C. As a part of the Work of this Section, make changes in the sheaves, belts, and dampers or the addition of dampers required for correct balance of the new work as required by the TAB firm, at no additional cost to the Owner.
- D. Fully examine the existing system to be balanced, to determine whether or not sufficient volume dampers, balancing valves, thermometers, gauges, pressure and temperature taps, means of reading static pressure and total pressure in duct systems, means of determining water flow, and other means of taking data needed for proper water and air balancing are existing. Submit to the Engineer in writing a listing of omitted items considered necessary to balance existing systems. Submit the list and proposal as a cost add item.
- E. Verify that fresh air louvers are free of blockage, coils are clean and fresh air ducts to each air handling unit have individually adjustable volume regulating dampers.
- F. Provide, correct, repair, or replace deficient items or conditions found during the testing, adjusting, and balancing period.
- G. In order that systems may be properly tested, balanced, and adjusted as specified, operate the systems at no expense to the Owner for the length of time necessary to properly verify their completion and readiness for TAB period.
- H. Project construction schedules shall provide time to permit the successful completion of TAB services prior to Substantial Completion. Complete, operational readiness, prior to commencement of TAB services, shall include the following services of the Contractor:
1. Construction status of building shall permit the closing of doors, windows,

ceilings installed and penetrations complete, to obtain project operating conditions.

2. AIR DISTRIBUTION SYSTEMS:

- a. Verify installation for conformity to design. Supply, return, and exhaust ducts terminated and pressure tested for leakage as specified.
- b. Volume and fire dampers properly located and functional. Dampers serving requirements of minimum and maximum outside air, return and relief shall provide tight closure and full opening, smooth and free operation.
- c. Supply, return, exhaust and transfer grilles, registers and diffusers shall be installed.
- d. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be blanked and sealed to eliminate excessive bypass or leakage of air.
- e. Fans (supply and exhaust) operating and verified for freedom from vibrations, proper fan rotation and belt tension; overload heater elements shall be of proper size and rating; record motor amperage and voltage and verify that these functions do not exceed nameplate ratings.
- f. Furnish or revise fan drives or motors as necessary to attain the specified air volumes.

3. WATER CIRCULATING SYSTEMS:

- a. Position valves pertinent to system design and require operation to permit full flow of water through system components. Operate hydronic systems under full flow conditions until circulating water is clean. Remove and clean strainers as required during this cycle of operation.
- b. For retrofit projects, record each existing pump motor amperage and voltage. Readings shall not exceed nameplate rating.
- c. Verify, on new equipment, electrical starter overload heater elements to be of proper size and rating.
- d. Ensure that water circulating systems shall be full of water and free of air; expansion tanks set for proper water level, and air vents installed at high points of systems and operating freely. Advise Engineer of deficiencies.
- e. Check and set operating temperatures of heat exchangers to design requirements.
- f. The various existing water circulating systems shall be cleaned, filled, purged of air, and put into operation before hydronic balancing.

4. AUTOMATIC CONTROLS:

- a. Verify that control components are installed in accordance with project documents and functional, electrical interlocks, damper sequences, air and water resets, fire and freeze stats.
- b. Controlling instruments shall be functional and set for design operating conditions. Factory precalibration of room thermostats and pneumatic equipment will not be acceptable.
- c. The temperature regulation shall be adjusted for proper relationship between the controlling instruments and calibrated by the TAB Contractor. Advise Engineer of deficiencies or malfunctions.

- I. Contractor shall repair any insulation removed from piping system by TAB Contractor during water balancing.

3.2 SERVICES OF THE TAB FIRM

- A. The TAB firm will act as liaison between the Owner, Engineer, and the Contractor and inspect the installation of mechanical piping system, sheet metal work, temperature controls and other component parts of the heating, air conditioning and ventilating

systems being retrofitted, repaired, or added under this Contract. The reinspection of the Work will cover that part related to proper arrangement and adequate provision for the testing and balancing and will be done when the Work is 80 percent complete.

- B. Upon completion of the installation and start-up of the mechanical equipment, to check, adjust, and balance system components to obtain optimum conditions in each conditioned space in the building. Prepare and submit to the Engineer complete reports on the balance and operations of the systems.
- C. Measurements and recorded readings of air, water, and electricity that appear in the reports will be done by the permanently employed technicians or engineers of the TAB firm.
- D. Make an inspection in the building during the opposite season from that in which the initial adjustments were made. At the time, make necessary modifications to the initial adjustments required to produce optimum operation of system components to affect the proper conditions as indicated on the Drawings. At time of opposite season check-out, the Owner's representative will be notified before readings or adjustments are made.
- E. In fan systems, the air quantities indicated on the Drawings may be varied as required to secure a maximum temperature variation of two degrees within each separately controlled space, but the total air quantity indicated for each zone must be obtained. It shall be the obligation of the Contractor to furnish or revise fan drive and motors if necessary, without cost to the Owner, to attain the specified air volumes.
- F. Contractor shall utilize ultrasonic flow meter to balance water flow of existing water system if the original pressure drop data is not available. Contractor shall remove insulation as necessary to use flow meter.

### 3.3 PROFESSIONAL REPORT

- A. Before the final acceptance of the report is made, the TAB firm will furnish the Engineer the following data to be approved by the Owner and Engineer:
  - 1. Summary of main supply, return and exhaust duct pitot tube traverses and fan settings indicating minimum value required to achieve specified air volumes.
  - 2. A listing of the measured air quantities at each outlet corresponding to the temperature tabulation as developed by the Engineer and TAB firm.
  - 3. Air quantities at each return and exhaust air handling device.
  - 4. Static pressure readings entering and leaving each supply fan, exhaust fan, filter, coil, balancing dampers and other components of the systems. Including the retrofit Work. These readings will be related to performance curves in terms of the CFM handled if available.
  - 5. Motor current readings at each equipment motor on load side of capacitors. The voltages at the time of the reading shall be listed.
  - 6. The final report shall certify test methods and instrumentation used, final velocity reading obtained, temperatures, pressure drops, RPM of equipment, amperage of motors, air balancing problems encountered, recommendations and uncompleted punch list items. The test results will be recorded on standard forms.
  - 7. A summary of actual operating conditions shall be included with each system outlining normal and ventilation cycles of operation. the final report will act as a reference of actual operating conditions for the Owner's operating personnel.

### 3.4 BALANCING AIR CONDITIONING SYSTEM

A. GENERAL:

1. Place all equipment into full operation, and continue operating during each working day of balancing and testing. If the air conditioning system is balanced during Off-Peak cooling season Contractor shall return to rebalance air side system as required to put system in proper balance at that season.
2. The Contractor shall submit detailed balancing and recording forms for approval. After approval by the Engineer, prepare complete set of forms for recording test data on each system. All Work shall be done under the supervision of a Registered Professional Engineer. All instruments used shall be accurately calibrated to within 1% of scale and maintained in good working order.
3. Upon completion of the balancing and testing, the TAB Contractor shall compile the test data in report forms, and forward five copies to the Engineer for evaluation.
4. The final report shall contain logged results of all tests, including such data as:
  - a. Tabulation of air volume at each outlet.
  - b. Outside dry bulb and wet bulb temperature.
  - c. Inside dry bulb and wet bulb temperatures in each conditioned space room or area.
  - d. Actual fan capacities and static pressures. Motor current and voltage readings at each fan.

B. AIR SYSTEMS: Perform the following operations as applicable to balance and test systems:

1. Check fan rotation.
2. Check filters (balancing shall be done with clean filters).
3. Test and adjust blower rpm to design requirements.
4. Test and record motor full load amperes.
5. Test and record system static pressures, suction and discharge.
6. Test and adjust system for design cfm, return air and outside air ( $\pm 2\%$ ). Change-out fan sheaves as required to balance system.
7. Test and record entering air temperatures, db and wb.
8. Test and record leaving air temperatures, db and wb.
9. Adjust all zones to design cfm ( $\pm 2\%$ ).
10. Test and adjust each diffuser, grille, and register to within 5% of design.

C. AIR DUCT LEAKAGE: (From SMACNA Duct Standards latest edition) Test all ductwork (designed to handle over 1000 CFM) as follows:

1. Test apparatus  
The test apparatus shall consist of:
  - a. A source of high pressure air--a portable rotary blower or a tank type vacuum cleaner.
  - b. A flow measuring device consisting of straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps. Each orifice assembly shall be accurately calibrated with its own calibration curve. Pressure and flow readings shall be taken with U-tube manometers.
2. Test Procedures
  - a. Test for audible leaks as follows:
    - 1) Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
    - 2) Start the blower with its control damper closed.
    - 3) Gradually open the inlet damper until the duct pressure reaches

- 4) Survey all joints for audible leaks. Mark each leak and repair after shutting down blower. Do not apply a retest until sealants have set.
- b. After all audible leaks have been sealed, the remaining leakage should be measured with the orifice section of the test apparatus as follows:
  - 1) Start blower and open damper until pressure in duct reaches 25% in excess of designed duct operating pressure.
  - 2) Read the pressure differential across the orifice on manometer No. 2. If there is no leakage, the pressure differential will be zero.
  - 3) Total allowable leakage shall not exceed one (1) percent of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
  - 4) Even though a system may pass the measured leakage test, a concentration of leakage at one point may result in a noisy leak which must be corrected.
- D. DX SYSTEMS:
  1. Test and record suction and discharge pressures at each compressor and record ambient air temperature entering the condensing coils.
  2. Test and record unit full load amps and voltage.
  3. Test and record staging and unloading of unit required by sequence of operation or drawing schedule.
- E. Automatic temperature controls shall be calibrated; and all thermostats and dampers adjusted so that the control system is in proper operating condition, subject to the approval of the Engineer/Owner.
- F. The TAB Contractor shall report to Engineer all air distribution devices or other equipment that operate noisily so that corrective measures may be implemented by the Contractor at no additional cost to the Owner or Architect/Engineer.

**END OF SECTION**

## **SECTION 23 07 13 - DUCT INSULATION**

### **PART 1 - GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods is included as a part of this Section as though written in full in this document.

#### **1.2 WORK INCLUDED**

- A. Ductwork system insulation.

#### **1.3 RELATED SECTIONS**

- A. Section 23 05 29 - Hangers and Support for HVAC Piping and Equipment
- B. Section 23 05 53 – Identification for HVAC Piping and Equipment
- C. Section 23 31 13 – Metal Ductwork

#### **1.4 REFERENCE STANDARDS**

- A. ASTM International. (ASTM)
- B. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE).
- C. North American Insulation Manufacturers Association (NAIMA).
- D. National Fire Protection Association (NFPA).
- E. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).
- F. Underwriter's Laboratories (UL).
- G. Underwriter's Laboratories Environmental (UL Environment).

#### **1.5 QUALITY ASSURANCE**

- A. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.
- B. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) that is UL Classified per UL 723 or with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.
  - 1. Exception: Outdoor mechanical insulation may have flame spread index of 75 and smoke developed index of 150.
- C. Duct and plenum insulation shall comply with minimum R-value requirements of 2021 International Energy Conservation Code and ASHRAE 90.1 - 2019.

- D. Adhesive and other material shall comply with NFPA and NBFU Standards No. 90A and 90B.

#### 1.6 WARRANTY

- A. Warrant the Work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from either defective, or nonconforming materials and workmanship.
- B. Defects shall include, but not be limited to, the following:
  - 1. Mildewing.
  - 2. Peeling, cracking, and blistering.
  - 3. Condensation on exterior surfaces.

#### 1.7 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, product variations, and accessories.

#### 1.8 DELIVERY, STORAGE AND HANDLING

- A. Deliver insulation, coverings, cements, adhesives, and coatings to site in unopened containers with manufacturer's stamp, clearly labeled with flame and smoke rating, affixed showing fire hazard indexes of products.
- B. Protect insulation against dirt, water and chemical and mechanical damage. Do not install damaged or wet insulation; remove such from project site.

### PART 2 - PRODUCTS

#### 2.1 GENERAL DESCRIPTION

- A. The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and approved before any insulation is installed.
- B. A sample quantity of each type of insulation and each type of application shall be installed and approval secured prior to proceeding with the main body of the Work.

#### 2.2 ACCEPTABLE MANUFACTURERS

- A. Glass mineral wool materials shall be as manufactured by Knauf Insulation, Certain-Teed, Johns-Manville or Owens-Corning and shall have the same thermal properties, density, fire rating, vapor barrier, etc., as the types specified herein, subject to review by the Engineer.
- B. Adhesives shall be as manufactured by Minnesota Mining, Arabol, Benjamin-Foster, Armstrong or Insulmastic, Inc., and shall have the same adhesive properties, fire rating, vapor seal, etc., as the types specified herein, subject to review by the Engineer.
- C. Ceramic fiber materials shall be as manufactured by Primer Refractories, A.P. Green

Refractories or approved equal.

### PART 3 - EXECUTION

#### 3.1 GENERAL

- A. All insulation shall be installed in accordance with the manufacturer's recommendations and printed installation instructions.
- B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.

#### 3.2 EXTERNAL DUCT INSULATION

- A. Fasten all longitudinal and circumferential laps with outward clinching staples 3" on center. On rectangular ducts over 24" wide apply as above and hold insulation in place on bottom side with mechanical pins and clips on 12" centers.
- B. Seal all joints, fastener penetrations and other breaks in vapor barrier with 3-inch wide strips of white glass fabric embedded between two coats of vapor barrier mastic, Childers CP-30 or approved equal.
- C. All external duct insulation shall be Knauf Insulation Atmosphere Duct Wrap with ECOSE Technology, Johns Manville Microlite EQ duct wrap insulation with reinforced aluminum facing or approved equal.
- D. External duct wrap is required on all outside air ducts, supply and return air ducts that are not internally insulated. External duct wrap is also required on all exhaust and relief air ducts that are used in airside energy recovery systems. Any exhaust ductwork located in an unconditioned space shall also be provided with external duct wrap. Duct wrap shall be provided as follows:
  - 1. 1½" thick, 1.0 PCF density minimum; minimum installed R-value of 4.2 when ducts are located in conditioned spaces.
  - 2. 2" thick with a minimum installed R-value of 6 when ducts are located in unconditioned spaces, such as ceiling plenum space.
- E. Any ductwork located in an air plenum that is comprised of materials that do not comply with the 25/50 flame and smoke rating per ASTM E 84 testing requirements shall be provided with a single layer of duct wrap to establish a noncombustible rating per ASTM E 136. Duct wrap products which are approved for such non-compliant combustible duct materials located in air plenums shall be 3M Fire Barrier Plenum Wrap 5A+ or Unifrax FyreWrap 0.5 Plenum. Insulation products for this application shall be installed in strict accordance with the manufacturer's instructions.

#### 3.3 DUCT LINER

- A. Duct liner shall be kept clean and dry during transportation, storage, installation, and throughout the construction process care should be taken to protect the liner from exposure to the elements or damage from mechanical abuse.
- B. All portions of duct designed to receive duct liner shall be completely covered with liner as specified. The smooth, black, mat facing or acrylic-coated surfaces with flexible glass cloth reinforcement shall face the airstream. All duct liner shall be cut to assure tight, overlapped corner joints. The top pieces shall be supported by the sidepieces. Duct liner

shall be installed following the guidelines in the NAIMA "Duct Liner Installation Standard".

- C. The duct liner shall be tested according to erosion test method in ASTM C 1071 and shall be guaranteed to withstand velocities in the duct system up to 6000 fpm without surface erosion.
- D. Duct liner shall be adhered to the sheet metal with full coverage of an approved adhesive that conforms to ASTM C 916, and all exposed leading edges and transverse joints shall be coated with Permacote factory-applied or field-applied edge coating and shall be neatly butted without gaps. Shop or field cuts shall be liberally coated with Johns Manville SuperSeal® duct butter and Edge Treatment or approved adhesive.
- E. Metal nosings shall be securely installed over transversely oriented liner edges facing the airstream at forward discharge and at any point where lined duct is preceded by unlined duct.
- F. When velocity exceeds 4000 fpm (20.3 m/sec), use metal nosing on every leading edge. Nosing may be formed on duct or be channel or zee attached by screws, rivets or welds.
- G. The liner shall further be secured with Graham welding pins and washers on not more than 18 inch centers both vertical and horizontal surfaces, and the pins and washers shall be pointed up with adhesive.
- H. Duct liner shall be Knauf Insulation Atmosphere Duct Liner with ECOSE Technology, Johns Manville Linacoustic RC duct liner with factory-applied edge coating and acrylic coating on the mat surface of airstream side or approved equal. The liner shall meet the Life Safety Standards as established by NFPA 90A and 90B, FHC 25/50 and Limited Combustibility and the air stream surface coating should contain an immobilized, EPA-registered, anti-microbial agent so it will not support microbial growth as tested in accordance with ASTM G21 and G22. The duct liner shall conform to the requirements of ASTM C 1071, UL 2824, with an NRC not less than .70 as tested per ASTM C 423 using a Type "A" mounting, and a thermal conductivity no higher than 0.24 BTU•in/(hr•ft<sup>2</sup>•°F) at 75°F mean temperature.
- I. Line supply and return ductwork at connection of HVAC unit to a point of 15 feet upstream and downstream of the equipment and in return air boots. Attach with full cover coat of cement, duct dimensions up to 16 inches; provide stick clips or screws and cap for dimensions over 16 inches, spaced 16 inches o.c. maximum. Provide sheet metal liner cap over all leading edges of internal insulation exposed to air stream.
- J. Duct liner shall be provided as follows:
  - 1. 1" Thick, 1.5 PCF density minimum; minimum installed R-value of 4.2 when ducts are located in conditioned spaces.
  - 2. 1 ½" Thick with a minimum installed R-value of 6 when ducts are located in unconditioned spaces, such as ceiling plenum space.
  - 3. 2" Thick with a minimum installed R-value of 8 when ducts are located outdoors.

### 3.4 EXPOSED DUCTWORK LOCATED INDOORS

- A. Duct routed exposed in occupied spaces shall be double wall.
- B. Round and flat oval duct routed exposed shall be double wall with perforated inner liner and 1" thick layer of glass mineral wool insulation as manufactured by United McGill Company model no. Acousti-27 or approved equal. Insulation density shall be a minimum of 1.0 PCF.

### 3.5 EXPOSED DUCT LOCATED OUTDOORS

- A. All duct located outdoors shall be internally lined as specified and shall have a 2" thick, 6 lb. density rigid board external duct insulation, finished with aluminum jacketing.
- B. Paint non-insulated duct. Coordinate color with Architect.

### 3.6 AIR DEVICE AND MISCELLANEOUS DUCT INSULATION

- A. The backside of all supply air devices shall be insulated with taped and sealed 1½ inch thick external duct wrap.
- B. The contractor shall install an additional layer of 1-½ inch thick external glass mineral wool duct wrap on any portion of the supply air, return air, outside air, or exhaust air system that has condensation forming during any period of operation. The insulation shall be taped and vapor-sealed and located until all evidence of the condensation has been eliminated, at no additional cost to the Owner.

### 3.7 KITCHEN GREASE HOOD EXHAUST DUCT

- A. All type I kitchen range hood exhaust duct shall be enclosed with 2-hour fire rated enclosure.
- B. The duct enclosure shall be sealed around the duct at the points of penetration with an approved fire barrier sealant per ASTM E 1966. Sealant shall be 3M CP 25WB+ or 303 fire barrier caulk and putty.
- C. The enclosure shall be separated from the duct by at least 3 inches and not more than 12 inches.
- D. Cleanout openings at exhaust duct with access openings at the fire rated enclosure and access doors shall be provided at each duct offset and as required for proper operation and maintenance.
- E. As an alternate method, the contractor may use two layers of 2-hour fire rated duct wrap such as 3M Fire Barrier Duct Wrap 615+ or Unifrax FyreWrap Elite 1.5 in lieu of the fire rated enclosure, provided that all the following constraints are satisfied:
  - a. Duct wrap system shall be tested per ASTM E 2336 internal fire testing and have an achieved minimum fire resistance rating of 2 hours.
  - b. Product shall be approved by the local Authority Having Jurisdiction (AHJ).
  - c. Duct wrap system shall be mechanically attached to the duct using steel banding and/or weld pins per manufacturer's instructions.
  - d. Duct wrap system shall be installed in strict accordance with the manufacturer's instructions, including but not limited to zero clearance to combustibles at all locations on the wrap surface.
- F. Insulation and all other requirements shall be provided per local codes.

### 3.8 DRYER VENT DUCT

- A. All dryer vent duct routed within an air plenum shall be enclosed within a 1-hour fire rated enclosure.
- B. The duct enclosure shall be sealed around the duct at the points of penetration with an

approved fire barrier sealant per ASTM E 1966. Sealant shall be 3M CP 25WB+ or 303 fire barrier caulk and putty.

- C. The enclosure shall be separated from the duct by at least 3 inches and not more than 12 inches.
- D. Cleanout openings at exhaust duct with access openings at the fire rated enclosure and access doors shall be provided at each duct offset and as required for proper operation and maintenance.
- E. As an alternate method, the contractor may use a single layer of 1-hour fire rated duct wrap such as 3M Fire Barrier Duct Wrap 615+ or Unifrax FyreWrap Elite 1.5 in lieu of the fire rated enclosure, provided that all the following constraints are satisfied:
  - a. Duct wrap system shall be tested per ASTM E 2336 internal fire testing and have an achieved minimum fire resistance rating of 1 hour.
  - b. Product shall be approved by the local Authority Having Jurisdiction (AHJ).
  - c. Duct wrap system shall be mechanically attached to the duct using steel banding and/or weld pins per manufacturer's instructions.
  - d. Duct wrap system shall be installed in strict accordance with the manufacturer's instructions, including but not limited to zero clearance to combustibles at all locations on the wrap surface.
- F. Insulation and all other requirements shall be provided per local codes.

**END OF SECTION**

## **SECTION 23 07 16 - HVAC EQUIPMENT INSULATION**

### **PART 1 – GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 – Basic Materials and Methods is included as a part of this Section as though written in full in this document.

#### **1.2 SCOPE**

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for Owner's use.
- B. Work specified elsewhere.
  - 1. Basic materials and methods.
  - 2. Piping systems.
  - 3. Air distribution equipment.

#### **1.3 REFERENCE STANDARDS**

- A. ASTM International. (ASTM)
- B. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE).
- C. North American Insulation Manufacturers Association (NAIMA).
- D. National Fire Protection Association (NFPA).
- E. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).
- F. Underwriter's Laboratories (UL).
- G. Underwriter's Laboratories Environmental (UL Environment).

#### **1.4 WARRANTY**

- A. Warrant the Work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from either defective or nonconforming materials and workmanship.
- B. Defects shall include, but not be limited to, the following:
  - 1. Mildewing.
  - 2. Peeling, cracking, and blistering.
  - 3. Condensation on exterior surfaces.

#### **1.5 SUBMITTALS**

- A. **SHOP DRAWINGS:** Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.

- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, product variations, and accessories.

#### 1.6 DELIVERY AND STORAGE

- A. Deliver insulation, coverings, cements, adhesives, and coatings to site in unopened containers with manufacturer's stamp, clearly labeled with flame and smoke rating, affixed showing fire hazard indexes of products.
- B. Protect insulation against dirt, water and chemical and mechanical damage. Do not install damaged or wet insulation; remove such from project site.

### PART 2 – PRODUCTS

- 2.1 It is the intent of these specifications to secure superior quality workmanship resulting in an absolutely satisfactory installation of insulation from the standpoint of both function and appearance. Particular attention shall be given to valves, fittings, pumps, etc., requiring low temperature insulation to insure full thickness of insulation and proper application of the vapor seal. All flaps of vapor barrier jackets and/or canvas covering must be neatly and securely smoothed and sealed down.
- 2.2 The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and reviewed before any insulation is installed.
- 2.3 A sample quantity of each type of insulation and each type application shall be installed and reviewed prior to proceeding with the main body of the work. Condensation caused by improper installation of insulation shall be corrected by Installing Contractor. Any damage caused by condensation shall be made good at no cost to the Owner or Architect/Engineer.
- 2.4 Glass mineral wool materials as manufactured by Knauf Insulation, Owens/Corning, Certain-Teed or Johns Manville will be acceptable, if they comply with the specifications.
- 2.5 All insulation shall have composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to insulation) fire and smoke hazard as tested by Procedure ASTM E084, NFPA 255 and UL 723 not exceeding:
  - Flame Spread 25
  - Smoke Developed 50
- 2.6 All HVAC equipment insulation shall comply with minimum requirements of 2015 International Energy Conservation Code and ASHRAE 90.1 - 2013.
- 2.7 Accessories, such as adhesives, mastics and cements shall have the same component ratings as listed above.
- 2.8 All products or their shipping cartons shall have a label affixed, indicating flame and smoke ratings do not exceed the above requirements.

### PART 3 – EXECUTION

- 3.1 All insulation shall be installed in accordance with the manufacturer's recommendations and printed installation instructions.

3.2 All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.

### 3.3 CHILLED WATER PUMPS

- A. Shall be insulated with Knauf Insulation Board with ECOSE Technology, Certain-Teed IB-600 or equal, rigid insulation board, 2" thick, cut and formed into a box and secured in place with 3/4" wide x .020 galvanized bands spaced on 9" centers. Bands shall be pulled snug over sheets of insulation board. All joints shall be well and neatly fitted and so arranged that the assembly may be dismantled with ease permitting access to the pump. All voids on the interior of box shall be filled with glass mineral wool blanket insulation. Exterior shall be finished with a trowel coat of Foster's 30-35 vapor barrier mastic, a layer of 1" mesh galvanized wire, and a coat of J.M. #352 cement. Final finish shall be an eight ounce canvas jacket, pasted and sealed in place with Foster's 30-36 Seafas.
- B. Pipe insulation shall be extended over all cold parts of chilled water pumps not directly over drainage basin of pump base.

### 3.4 BOILER EXHAUST SYSTEM

- A. Insulate boiler stack, breaching and induced draft fan housing in contact with flue gases, with 1-inch thick high temperature, spun glass mineral wool semi-rigid board. Knauf Insulation Elevated Temperature Board with ECOSE Technology, Johns-Manville 1000 Spin-Glass or approved equal, secured between outer facing of 1-inch galvanized wire mesh. Calcium silicate insulation, Johns-Manville Thermo-12 Gold or approved equal, may be applied at the contractor's option followed by application of 1-inch galvanized wire mesh.
- B. In exposed areas, apply 1 1/4-inch coat of insulating and finishing cement, Ryder "V" One Coat or approved equal, troweled to a smooth surface. After cement has dried, surfaces shall be weatherproofed using 2 coats of mastic, Childers CP-10, with a layer of white glass cloth reinforcing embedded between coats.

**END OF SECTION**

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## **SECTION 23 07 19 – HVAC PIPING INSULATION**

### **PART 1 - GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 – Basic Materials and Methods is included as a part of this Section as though written in full in this document.

#### **1.2 SCOPE**

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for Owner's use.
- B. Furnish and install piping insulation to:
  - 1. Chilled water and heating hot water piping.
  - 2. Condensate drain piping.
  - 3. Refrigerant piping.
  - 4. All pipes subject to freezing conditions shall be insulated.
- C. Work specified elsewhere.
  - 1. Painting.
  - 2. Pipe hangers and supports.
- D. For insulation purpose piping is defined as the complete piping system including supplies and returns, pipes, valves, automatic control valve bodies, fittings, flanges, strainers, thermometer well, unions, reducing stations, and orifice assemblies.

#### **1.3 RELATED SECTIONS**

- A. Section 23 05 29 - Hangers and Support for HVAC Piping and Equipment
- B. Section 23 05 53 – Identification for HVAC Piping and Equipment

#### **1.4 REFERENCE STANDARDS**

- A. ASTM International. (ASTM)
- B. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE).
- C. North American Insulation Manufacturers Association (NAIMA).
- D. National Fire Protection Association (NFPA).
- E. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).
- F. Underwriter's Laboratories (UL).
- G. Underwriter's Laboratories Environmental (UL Environment).

## 1.5 WARRANTY

- A. Warrant the Work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from either defective or nonconforming materials or workmanship.
- B. Defects shall include, but not be limited to, the following:
  - 1. Mildewing.
  - 2. Peeling, cracking, and blistering.
  - 3. Condensation on exterior surfaces.

## 1.6 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, project variations, and accessories.

## 1.7 DELIVERY AND STORAGE

- A. Deliver insulation, coverings, cements, adhesives, and coatings to site in unopened containers with manufacturer's stamp, clearly labeled with flame and smoke rating, affixed showing fire hazard indexes of products.
- B. Protect insulation against dirt, water and chemical and mechanical damage. Do not install damaged or wet insulation; remove such from project site.

## PART 2 - PRODUCTS

- 2.1 It is the intent of these specifications to secure superior quality workmanship resulting in an absolutely satisfactory installation of insulation from the standpoint of both function and appearance. Particular attention shall be given to valves, fittings, pumps, etc., requiring low temperature insulation to insure full thickness of insulation and proper application of the vapor seal. All flaps of vapor barrier jackets and/or canvas covering must be neatly and securely smoothed and sealed down.
- 2.2 The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and reviewed prior to installation.
- 2.3 A sample quantity of each type of insulation and each type application shall be installed and accepted prior to proceeding with the main body of the work. Condensation caused by improper installation of insulation shall be corrected by Installing Contractor. Any damage caused by condensation shall be made good at no cost to the Owner or Architect/Engineer.
- 2.4 All insulation shall have composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to insulation) fire and smoke hazard as tested by Procedure ASTM E 84, NFPA 255 and UL 723 not exceeding:

Flame Spread 25  
Smoke Developed 50

- 2.5 All HVAC piping insulation shall comply with minimum requirements of 2015 International Energy Conservation Code and ASHRAE 90.1 - 2013.
- 2.6 Accessories, such as adhesives, mastics and cements shall have the same component ratings as listed above.
- 2.7 All products or their shipping cartons shall have a label affixed, indicating flame and smoke ratings do not exceed the above requirements.
- 2.8 Any piping located in an air plenum that is comprised of materials that do not comply with the 25/50 flame and smoke rating per ASTM E 84 testing requirements shall be provided with a single layer of high-temperature insulation to establish a noncombustible rating per ASTM E 136. Insulation products which are approved for such non-compliant combustible piping materials located air plenums shall be 3M Fire Barrier Plenum Wrap 5A+ or Unifrax FyreWrap 0.5 Plenum. Insulation products for this application shall be installed in strict accordance with the manufacturer's instructions.
- 2.9 APPROVED MANUFACTURERS
- A. Calcium silicate materials shall be as manufactured by Johns Manville.
  - B. Glass mineral wool materials shall be as manufactured by Knauf Insulation, Johns Manville or Owens-Corning and shall have the same thermal properties, density, fire rating, vapor barrier, etc., as the types specified herein, subject to review by the Engineer.
  - C. Adhesives shall be as manufactured by Childers, Foster, HB Fuller or Armacell, and shall have the same adhesive properties, fire rating, vapor seal, etc., as the types specified herein, subject to review by the Engineer.
  - D. Flexible elastomeric cellular thermal insulation by Armacell.
  - E. Phenolic foam insulation shall be as manufactured by Kooltherm Insulation (Koolphen).
  - F. Metal jacketing and fitting covers shall be as manufactured by Childers or RPR Products.
- 2.10 MATERIALS
- A. CHILLED WATER: Provide Phenolic foam with ASJ jacket and all joints sealed
  - B. HEATING HOT WATER PIPE: Provide glass mineral wool pipe insulation with ASJ-SSL jacket or phenolic foam with ASJ and all joints sealed.
  - C. CONDENSATE DRAINAGE PIPING: Flexible elastomeric cellular thermal insulation, model "AP-2000", fire rated for use in environmental air plenums; insulation not required when piping is exposed on roof.
  - D. REFRIGERANT PIPING: Flexible elastomeric cellular thermal insulation, model "AP-2000", fire rated for use in environmental air plenums. Apply manufacturers recommended finish and sealant for exterior applications.
  - E. METAL JACKETING: Utilize Childers "Strap-On" jacketing. Provide preformed fitting covers for all elbows and tees.

### PART 3 - EXECUTION

- 3.1 All insulation shall be installed in accordance with the manufacturer's recommendations and printed installation instructions, including high density inserts at all hangers and pipe supports to prevent compression of insulation.
- 3.2 All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.
- 3.3 All heat recovery piping between air conditioning equipment and hydronic or domestic hot water piping shall be insulated per the High Temperature Surfaces Schedule in Part 4.
- 3.4 All condenser water piping located in a ceiling plenum shall be insulated per the Low Temperature Surfaces Schedule in Part 4.
- 3.5 Pipes located outdoors or in tunnels shall be insulated same as concealed piping and shall have a jacket of 0.016 inch thick, smooth aluminum with longitudinal modified Pittsburgh Z-Lock seam and 2 inch overlap. Jacketing shall be easily removed and replaced without damage. All insulation butt joints shall be sealed with gray silicone. Galvanized banding is not acceptable.
- 3.6 All insulated piping located over driveways shall have an aluminum shield permanently banded over insulation to protect it from damage from car antennas.
- 3.7 WATER PIPE INSULATION INSTALLATION
  - A. The insulation shall be applied to clean, dry pipes with all joints firmly butted together. Where piping is interrupted by fittings, flanges, valves or hangers and at intervals not to exceed 25 feet on straight runs, an isolating seal shall be formed between the vapor barrier jacket and the bare pipe. The seal shall be by the applications of adhesive to the exposed insulation joint faces, carried continuously down to and along 4 inches of pipe and up to and along 2 inches of jacket.
  - B. Pipe fittings and valves shall be insulated with pre-molded or shop fabricated glass mineral wool covers finished with two brush coats of vapor barrier mastic reinforced with glass fabric.
  - C. All under lap surfaces shall be clean and free of dust, etc. before the Joint is sealed. These laps shall be firmly rubbed to insure a positive seal. A brush coat of vapor retarder shall be applied to all edges of the vapor barrier jacket.
- 3.8 STANDBY-GENERATOR ENGINE EXHAUST PIPING
  - A. Entire engine exhaust pipe from exhaust manifold to outside terminal shall be enclosed in a 1" thick layer of calcium silicate insulation.
  - B. A second insulating layer of 1" thick calcium silicate shall cover the first layer.
  - C. Joints for the first and second layer shall be staggered.
  - D. Apply aluminum jacket over outer layer of insulation.
  - E. Insulate exhaust muffler in the same manner as the exhaust piping.
- 3.9 FIRE RATED INSULATION
  - A. All pipe penetrations through walls and concrete floors shall be fire rated by applying USG Thermafiber in the space between the concrete and the pipe.

- B. The penetration shall be additionally sealed by using 3M brand model CP 25 or 303 fire barrier caulk and putty.
- C. All fire rating material shall be insulated in accordance with manufacturer's printed instructions.

**PART 4 - SCHEDULES**

4.1 Provide all HVAC piping insulation to comply with the ASHRAE 90.1 Minimum Thickness Schedule.

4.2 **LOW TEMPERATURE SURFACES** **MINIMUM INSULATION THICKNESS**

- A. Condensate drain lines: 1 inch
- B. Chilled Water Piping:
  - 1. Located outdoors: 2 inch
  - 2. Located indoors:
    - a. 4 inch and smaller: 1 ½ inch
    - b. Larger than 4 inch: 2 inch
- C. Refrigerant Piping
  - 1. 1½" and smaller 1 inch
  - 2. Larger than 1½ inch 1 ½ inch

4.3 **HIGH TEMPERATURE SURFACES** **MINIMUM INSULATION THICKNESS**

- A. Hot Water Piping:
  - 1. Operating temperature 105°F or less: 1 inch
  - 2. Operating temperature higher than 105°F and pipe size 1¼ inch or smaller 1 ½ inch
  - 3. Operating temperature higher than 105°F and pipe size greater than 1¼ inch 2 inch
- B. Steam Piping:
  - 1. Pipe size 1½ inch and smaller 2 ½ inch
  - 2. Pipe size more than 1½ inch 3 inch

**END OF SECTION**

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## **SECTION 23 31 13 - METAL DUCTWORK**

### **PART 1 - GENERAL**

#### **1.1 WORK INCLUDED**

- A. Low pressure ductwork.
- B. Medium and high pressure ductwork.
- C. Casings.
- D. Underground buried ducts.
- E. Kitchen hood ductwork.
- F. Laboratory fume hood exhaust ductwork.
- G. Welding hood exhaust.
- H. Paint hood exhaust.
- I. Commercial dryer vent.
- J. Duct cleaning.

#### **1.2 RELATED SECTIONS**

Division 9 - Finishes: Weld priming, weather resistant, paint or coating.

- A. Section 23 02 00 - Basic Material and Methods.
- B. Section 23 05 29 – Hangers and Support for Piping and Equipment HVAC.
- C. Section 23 05 93 - Testing, Adjusting and Balancing.
- D. Section 23 07 13 - Duct Insulation.

#### **1.3 QUALITY ASSURANCE**

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of metal ductwork products of types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms with least 3 years of successful installation experience on projects with metal ductwork systems similar to that required for project.
- C. Codes and Standards:
  - 1. SMACNA Standards: Comply with latest SMACNA's "HVAC Duct Construction Standards, Metal and Flexible" for fabrication and installation of metal ductwork.
  - 2. ASHRAE90.1 Standards: Comply with ASHRAE Handbook, Equipment Volume, Chapter 1 "Duct Construction", for fabrication and installation of metal ductwork.
  - 3. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems", NFPA 90B "Standard for the Installation of Warm Air Heating and Air Conditioning Systems", and NFPA 96 Standard.

4. IECC 2015: Comply with 2015 International Energy Conservation Code.

1.4 GENERAL DESCRIPTION

- A. Extent of metal ductwork is indicated on drawings and in schedules, and by requirements of this section.

1.5 SUBMITTALS

- A. Submit shop drawings, duct fabrication standards and product data under provisions of Division One.
- B. Indicate duct fittings, particulars such as gauges, sizes, welds, and configuration prior to start of work.
- C. The contract documents are schematic in nature and are to be used only for design intent. The contractor shall prepare sheet metal shop drawings, fully detailed and drawn to scale, indicating all structural conditions, all plumbing pipe and light fixture coordination, and all offsets and transitions as required to permit the duct to fit in the space allocated and built. All duct revisions required as a result of the contractor not preparing fully detailed shop drawings will be performed at no additional cost.

1.6 DEFINITIONS

- A. Duct Sizes: Inside clear dimensions. For lined ducts, maintain indicated clear size inside lining. Where offsets or transitions are required, the duct shall be the equivalent size based on constant friction rate.
- B. Low Pressure: Low pressure ductwork shall be rated for an operating pressure of 2". Low pressure ductwork shall be defined as all return, exhaust, and outside air ducts, all supply ductwork associated with constant volume air handling units with a scheduled external static pressure of less than 2", and all supply ductwork downstream of terminal units in variable volume systems.
- C. Medium Pressure: Medium pressure ductwork shall be rated for an operating pressure of 4". Medium pressure ductwork shall be defined as all supply ductwork extending from variable volume air handling units to terminal units in variable volume systems with air handling units having a scheduled external static pressure of less than 4". The supply ductwork of constant volume air handling units having a scheduled external static pressure greater than 2" and less than 4" shall be rated for medium pressure.
- D. High Pressure: High pressure ductwork shall be rated for an operating pressure of 6", or the scheduled external pressure of the equipment it is connected to, whichever is greater. The supply ductwork of air handling units having a scheduled external static pressure greater than 4" shall be high pressure.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protection: Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings, use sheet metal end caps on any lined duct exposed to the weather.
- B. Storage: Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with waterproof wrapping.

## PART 2 - PRODUCTS

### 2.1 DUCTWORK MATERIALS

- A. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains and discolorations, and other imperfections, including those which would impair painting.
- B. Sheet Metal.: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A 527, lockforming quality, with G 90 zinc coating in accordance with ASTM A 525; and mill phosphatized for exposed locations.
- C. Stainless Steel Sheet: Where indicated, provide stainless steel complying with ASTM A167; Type 316; with No. 4 finish where exposed to view in occupied spaces, No. 1 finish elsewhere. Protect finished surfaces with mill-applied adhesive protective paper, maintained through fabrication and installation.
- D. Aluminum Sheet: Where indicated, provide aluminum sheet complying with ASTM B 209, Alloy 3003, Temper H14.

### 2.2 MISCELLANEOUS DUCTWORK MATERIALS

- A. General: Non-combustible and conforming to UL 181, Class 1 air duct materials.
- B. Flexible Ducts: Flexmaster U.S.A., Inc. Type 3M or approved equal, corrosive resistant galvanized steel formed and mechanically locked to inner fabric with 1" thick insulation when flexible ducts are located in conditioned spaces and with R-5 insulation when located in unconditioned spaces. Flexible duct shall have reinforced metalized outer jacket comply with UL 181, Class 1 air duct.
- C. Sealants: Hard-Cast "iron grip" or approved equal, non-hardening, water resistant, fire resistive and shall not be a solvent curing product. Sealants shall be compatible with mating materials, liquid used alone or with tape or heavy mastic.
- D. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.
  - 1. For exposed stainless steel ductwork, provide matching stainless steel support materials.
  - 2. For aluminum ductwork, provide aluminum support materials.

### 2.3 LOW PRESSURE DUCTWORK

- A. Fabricate and support in accordance with latest SMACNA Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- B. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes permitted except by approved shop drawings. Obtain engineer's approval prior to using round duct in lieu of rectangular duct.
- C. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide airfoil-

turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

- D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.
- E. Use crimp joints with bead for joining round duct sizes 6 inch smaller with crimp in direction of airflow.
- F. Use double nuts and lock washers on threaded rod supports.

#### 2.4 MEDIUM AND HIGH PRESSURE DUCTS

- A. Fabricate and support in accordance with SMACNA Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- B. Construct T's, bends, and elbows with radius of not less than 1½ times width of duct on centerline. Where not possible and where rectangular elbows are used, provide airfoil-turning vanes. Where acoustical lining is required, provide turning vanes of perforated metal with glass fiber insulation. Weld in place.
- C. Transform duct sizes gradually, not exceeding 15 degrees divergence and 30 degrees convergence.
- D. Fabricate continuously welded medium and high pressure round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints shall be minimum 4 inch cemented slip joint, brazed or electric welded. Prime coat welded joints.
- E. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

#### 2.5 CASINGS

- A. Fabricate casings in accordance with SMACNA Duct Construction Standards and SMACNA High Pressure Duct Construction Standards and construct for operating pressures indicated.
- B. Mount floor mounted casings on 4 inch high concrete curbs. At floor, rivet panels on 8 inch centers to angles. Where floors are acoustically insulated, provide liner of 18 gauge galvanized expanded metal mesh supported at 12 inch centers, turned up 12 inches at sides with sheet metal shields.
- C. Reinforce doorframes with steel angles tied to horizontal and vertical plenum supporting angles. Install hinged access doors where indicated or required for access to equipment for cleaning and inspection. Provide clear wire glass observation ports, minimum 6 X 6 inch size.
- D. Fabricate acoustic casings with reinforcing turned inward. Provide 16 gauge back facing and 22 gauge perforated front facing with 3/32 inch diameter holes on 5/32 inch centers. Construct panels 3 inches thick packed with 4.5 lb./cubic foot minimum glass fiber media, on inverted channels of 16 gauge.

#### 2.6 BURIED UNDERGROUND DUCTS

- A. Buried ducts may be concrete encased sheet metal or fiberglass reinforced plastic as indicated.

#### 2.7 KITCHEN HOOD EXHAUST DUCTWORK

- A. Fabricate in accordance with SMACNA Duct Construction Standards, and NFPA 96.
- B. Construct of 16 gauge carbon steel or 18 gauge stainless steel, using continuous external welded joints.

#### 2.8 DISHWASHER/SHOWER/LOCKER ROOM EXHAUST DUCTWORK

- A. All ductwork shall be stainless steel, one gauge heavier than that required for galvanized steel duct.
- B. Slope all duct to drain out grilles or provide drain line to floor drain.

#### 2.9 LABORATORY FUME HOOD EXHAUST DUCTWORK

- A. Construct of 18 gauge type 316 stainless steel.
- B. All welded construction.

#### 2.10 CHLORINE STORAGE AREA

- A. 18 gauge minimum galvanized steel.
- B. Three coat minimum, acid resistance, epoxy paint, minimum 6 mil dry film thickness total, inside of duct and outside of duct.
- C. Paint after fabrication including all taps and grilles.

#### 2.11 DUCT EXPOSED IN POOL ROOM

- A. 18 gauge minimum galvanized steel.
- B. Two coat galv-grip primer.
- C. Three coat minimum, acid resistant epoxy paint, minimum 6 mil dry film thickness total, exterior of duct, color to be selected by architect in the field.
- D. Paint after fabrication, including all hangers, taps, grilles, return air grilles and louvers.

#### 2.12 WELDING HOOD EXHAUST DUCT

- A. Construct of 18 gauge carbon steel.
- B. All welded construction.

#### 2.13 PAINT HOOD EXHAUST DUCT

- A. Construct of 18 gauge, Type 316 stainless steel.
- B. All welded construction.

## 2.14 COMMERCIAL DRYER VENT

- A. Construct of 18 gauge, Type 316 stainless steel.
- B. All welded construction.
- C. Provide hard duct connection to dryer.

## PART 3 - EXECUTION

### 3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Obtain manufacturer's inspection and acceptance of fabrication and installation of ductwork at beginning of installation.
- B. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- C. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- D. Connect terminal units to medium or high pressure ducts with four feet maximum length of flexible duct. Do not use flexible duct to change direction.
- E. Connect diffusers or troffer boots to low pressure ducts with 6 feet maximum, 4 feet minimum, length of flexible duct. Hold in place with strap or clamp.
- F. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- G. The interior surface of all ductwork shall be smooth. No sheet metal parts, tabs, angles, or anything else may project into the ducts for any reason, except as specified to be so. All seams and joints shall be external.
- H. All ductwork located exposed on roof shall be "crowned" to prevent water from ponding. Ref: Insulation for additional requirements.
- I. Where ducts pass through floors, provide structural angles for duct support. Where ducts pass through walls in exposed areas, install suitable sheet metal escutcheons as closers.
- J. All angles shall be carried around all four sides of the duct or group of ducts. Angles shall overlap corners and be welded or riveted.
- K. All ductwork shall be fabricated in a manner to prevent the seams or joints being cut for the installation of grilles, registers, or ceiling outlets.
- L. All duct hangers shall be attached to building structure. Cutting slots in roof or floor decking for hanger straps to be cast in concrete is not acceptable.

### 3.2 INSTALLATION OF FLEXIBLE DUCTS

- A. Maximum Length: For any duct run using flexible ductwork, do not exceed 6'-0" extended length.
- B. Installation: Install in accordance with Section III of SMACNA's, "HVAC Duct Construction Standards, Metal and Flexible".

### 3.3 REQUIREMENTS FOR DUCTS BURIED UNDERGROUND

- A. Slope underground ducts to plenums or low pump-out points at 1:500. Provide access doors for inspection.
- B. Coat buried, metal ductwork without factory jacket with one coat and seams and joints with additional coat of asphalt base protective coating.
- C. Insulate buried supply duct runs over 50 feet long with one inch thick insulation covered with plastic vapor barrier.
- D. Encase buried metal ductwork in 3 inch minimum of concrete. Provide adequate tie-down points to prevent ducts from floating during concrete placement. Introduce no heat into ducts for 20 days following placement of concrete.

### 3.4 REQUIREMENTS FOR UNIT CASINGS

- A. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

### 3.5 REQUIREMENTS FOR KITCHEN HOOD EXHAUST DUCT

- A. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout.
- B. Provide access openings in each change in direction, located on sides of duct 1½" minimum from bottom, and fitted with grease-tight covers of same material as duct
- C. Use stainless steel for ductwork exposed to view.

### 3.6 DUCTWORK APPLICATION SCHEDULE

AIR SYSTEM	MATERIAL
Low Pressure Supply	Galvanized Steel, Aluminum
Buried Supply or Return	Concrete, Glass Fiber Reinforced Plastic
Medium and High Pressure Supply	Galvanized Steel
Return and Relief	Galvanized Steel, Aluminum
General Exhaust	Galvanized Steel, Aluminum
Kitchen Hood Exhaust	Carbon Steel, Stainless Steel
Dishwasher/Shower/Locker Room Dryer Vent/Paint Hood Exhaust	Stainless Steel
Fume Hood Exhaust	Stainless Steel, Glass Fiber Reinforced Plastic if not in air plenum.

Outside Air Intake	Steel
Combustion Air	Steel
Emergency Generator Ventilation	Steel

### 3.7 DUCTWORK HANGERS AND SUPPORTS

- A. All ductwork shall be properly suspended or supported from the building structure. Hangers shall be galvanized steel straps or hot-dipped galvanized rod with threads pointed after installation. Strap hanger shall be attached to the bottom of the ductwork, provide a minimum of two screws one at the bottom and one in the side of each strap on metal ductwork. The spacing, size and installation of hangers shall be in accordance with the recommendations of the latest SMACNA edition.
- B. All duct risers shall be supported by angles or channels secured to the sides of the ducts at each floor with sheet metal screws or rivets. The floor supports may also be secured to ducts by rods, angles or flat bar to the duct joint or reinforcing. Structural steel supports for duct risers shall be provided under this Division.

### 3.8 AIR DUCT LEAKAGE: (From SMACNA Duct Standards Latest Edition) Test all ductwork (designed to handle over 1000 CFM) as follows:

#### A. Test apparatus

The test apparatus shall consist of:

- 1. A source of high pressure air--a portable rotary blower or a tank type vacuum cleaner.
- 2. A flow measuring device consisting of straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps. Each orifice assembly shall be accurately calibrated with its own calibration curve. Pressure and flow readings shall be taken with U-tube manometers.

#### B. Test Procedures

- 1. Test for audible leaks as follows:
- 2. Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
  - a. Start the blower with its control damper closed.
  - b. Gradually open the inlet damper until the duct pressure reaches 1.5 times the standard designed duct operating pressure.
  - c. Survey all joint for audible leaks. Mark each leak and repair after shutting down blower. Do not apply a retest until sealants have set.
- 3. After all audible leaks have been sealed, the remaining leakage should be measured with the orifice section of the test apparatus as follows:
  - a. Start blower and open damper until pressure in duct reaches 50% in excess of designed duct operating pressure.
  - b. Read the pressure differential across the orifice on manometer No. 2. If there is no leakage, the pressure differential will be zero.
  - c. Total allowable leakage shall not exceed one (1) percent of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.

- d. Even though a system may pass the measured leakage test, a concentration of leakage at one point may result in a noisy leak which, must be corrected.
- 4. Testing Report
  - a. Contractor shall provide a testing report for each air system to the engineer. The report shall indicate the completion of testing and compliance with testing specification.
  - b. All duct testing reports shall be included in the final close out documents.

### 3.9 DUCT SYSTEM CLEANING

- A. Duct system cleaning shall be performed in accordance with the current published standards of ASHRAE and NADCA.
- B. Duct system cleaning method used shall incorporate the use of vacuum collection devices that are operated continuously during cleaning. A vacuum device shall be connected to the downstream end of the section being cleaned through a predetermined opening. The vacuum collection device must be of sufficient power to render all areas being cleaned under negative pressure, such that containment of debris and the protection of the indoor environment is assured.
- C. All vacuum devices exhausting air inside the building shall be equipped with HEPA filters (minimum efficiency), including hand-held vacuums and wet-vacuums.
- D. All vacuum devices exhausting air outside the facility shall be equipped with Particulate Collection including adequate filtration to contain debris removed from the HVAC system. Such devices shall exhaust in a manner that will not allow contaminants to re-enter the facility. Release of debris outdoors must not violate any outdoor environmental standards, codes or regulations.
- E. Fibrous glass thermal or acoustical insulation elements present in any equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment, while the HVAC system is under constant negative pressure, and not permitted to get wet in accordance with applicable NADCA and NAIMA standards and recommendations.
- F. Duct cleaning method used shall not damage the integrity of the ductwork, nor damage porous surface materials such as liners inside the ductwork or system components.
- G. Replace the fiberglass material if there is any evidence of damage, deterioration, delamination, friable material, mold or fungus growth, or moisture such that fibrous glass materials cannot be restored by cleaning or resurfacing with an acceptable insulation repair coating.
- H. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
- I. Strip protective paper from stainless ductwork surfaces, and repair finish wherever it has been damaged.
- J. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

- K. Cleaning Report: Contractor shall provide a report to the Owner indicating the completion of duct cleaning per specification and areas of the duct system found to be damaged and/or in need of repair.

3.10 DUCT JOINTS AND SEAMS

- A. Seal all non-welded duct joints with duct sealant as indicated.

**END OF SECTION**

## **SECTION 23 41 00 - AIR FILTERS**

### **PART 1 - GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 23 02 00, are included as a part of this Section as though written in full in this document.

#### **1.2 SCOPE**

Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.

### **PART 2 - PRODUCTS**

#### **2.1 FILTERS**

- A. Air filters shall be medium efficiency ASHRAE pleated panels consisting of cotton and synthetic media, welded wire media support grid, and beverage board enclosing frame, Camfil Farr 30/30, 2-inch thick or approved equal.
- B. **APPROVED MANUFACTURERS:** The following manufacturers are approved subject to specification compliance.
  - 1. American Air Filter.
  - 2. Camfil.
  - 3. Airguard Industries, Inc.
  - 4. Cambridge.
  - 5. Filtration Group

#### **2.2 LOW VELOCITY FILTER SECTION**

- A. Filters shall be of the throwaway cartridge type in 24 inches X 24 inches X 2 inch frames. When installing multiple filters into slide-in frames tape adjacent filters together with duct tape to prevent bypassing of air around the filter. Media shall be rated at 500 feet per minute.
- B. Filtering media shall be formed of non-woven reinforced cotton fabric type filtering media bonded to 96% open area media support grid folded into a non-creased radial pleat design. The filter pack shall be bonded to the enclosing frame to prevent air bypass. Minimum Efficiency Reporting Value of MERV 8 when evaluated under the guidelines of ASHRAE Standard 52.2-2017. Initial resistance shall not exceed 0.23 inches water gauge at 350 FPM face velocity.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Install differential pressure switch to activate "Filter Dirty" light when pressure difference across filters reaches 0.5 inch W.G. (adjustable). Locate "filter dirty" lights in mechanical rooms with identifying label

- B. Install and relocate filters in the mechanical or the storage room in accordance with manufacturer's recommendations.
- C. Refer to Section 23 02 00 for additional filter information.

**END OF SECTION**

## **SECTION 23 81 33 - ROOFTOP HEATING AND COOLING UNITS (ELECTRIC COOLING - GAS HEATING)**

### **PART 1 - GENERAL**

#### **1.1 GENERAL REQUIREMENTS**

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 – Basic Materials and Methods is included as a part of this Section as though written in full in this document.

#### **1.2 SCOPE**

Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for Owner's use.

#### **1.3 RELATED SECTIONS**

- A. Section 23 02 00 – Basic Materials and Methods
- B. Section 23 05 13 – Common Motor Requirements for HVAC Equipment
- C. Section 23 05 26 – Variable Frequency Motor Speed Control for HVAC Equipment
- D. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment

#### **1.4 QUALITY ASSURANCE**

- A. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.
- B. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.
- C. AHRI 360 - Commercial and Industrial Unitary Air Conditioning Equipment testing and rating standard.
- D. ANSI/ASHRAE/IES 90 A - Energy Conservation in New Building Design Standard provides performance requirements to improve the utilization of energy in new buildings.
- E. AHRI 410 - Forced Circulation Air-Cooling and Air- Heating Coils Standard for establishing requirements for testing, rating and certification of ratings.
- F. ANSI/UL 465 - Central Cooling Air Conditioners Standard for safety requirements.
- G. AMCA 300 - Reverberant room method for sound testing of fans.
- H. ANS S1.32 - Precision methods for the determination of sound power levels of discrete frequency and narrow band noise sources in reverberation rooms.

#### **1.5 SUBMITTALS**

- A. Submit Shop drawings and product data under provisions of Division One.

- B. Shop drawings shall indicate components, dimensions, weights, required service clearances, and location and sizes of field connections. Indicate equipment, piping and connections and valves required for complete system.
- C. Product data shall include rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.
- D. Provide fan curves with specified operating point clearly identified.
- E. Submit manufacturer's installation instructions.

#### 1.6 OPERATION AND MAINTENANCE DATA

- A. Submit operation data.
- B. Include start-up instructions, maintenance data, controls, and accessories. Include trouble-shooting guide.
- C. Submit maintenance data.

#### 1.7 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to site. Comply with manufacturer's installation instructions for rigging, unloading and transporting units.
- B. Accept products on site and inspect for damage.
- C. Protect units from physical damage. Factory shipping covers and skids shall be kept in place until installation. Store in a clean dry place and protect from weather and construction traffic.

#### 1.8 WARRANTY

- A. Provide a full parts and labor warranty for one year from start-up or 18 months from shipment, whichever occurs first.
- B. Provide five-year warranty for compressors materials and labor.

#### 1.9 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
  - 1. Purpose of equipment.
  - 2. Principle of how the equipment works.
  - 3. Important parts and assemblies.
  - 4. How the equipment achieves its purpose and necessary operating conditions.
  - 5. Most likely failure modes, causes and corrections.
  - 6. On site demonstration.

### PART 2 – PRODUCTS

## 2.1 PRODUCTS

- A. Rooftop unit shall be packaged and include electric cooling and gas-fired heat, with capacity and modulating cooling and heating as shown on the drawings.
- B. Unit shall be factory-charged and tested, shall be UL-labeled and ARI-certified by Standard 210 and 270, and shall be AGA-certified.
- C. Unit casing shall be heavy-gauge galvanized steel or heavy-gauge aluminum with protective coat of baked enamel. Weatherproof access panels shall be provided for access to all parts requiring service.
- D. Compressor(s) shall be hermetic scroll type and shall be resiliently mounted to avoid vibration and noise. Compressor shall be provided with anti-slugging protection, crankcase heater, and time delay on recycling of the compressor. Two internal compressor motor thermal cutouts and a hot gas cutout shall protect the compressor in addition to high-pressure and low-pressure safeties. Standard controls shall permit operation down to 35 deg. F (2 deg. C), and compressor shall be locked out below this temperature.
- E. Condenser fan(s) shall be direct-driven and shall be designed for operation exposed to the weather.
- F. Condenser coils shall have a sub-cooling section.
- G. Refrigerant circuit shall include filter dryer, moisture indicator, sight glass, and gauge ports.
- H. Filter rack shall be provided for filters 2 in. thick and shall filter both outdoor air and return air. See Section 23 41 00 for type of filters, and the number of filter changes to be furnished with the equipment.
- I. Evaporator fan shall be quiet-type centrifugal blower, directly connected to an adjustable-speed motor or belt driven with an adjustable-pitch pulley on the motor.
- J. Heat exchanger shall be aluminized steel, designed for long life and quiet operation. Burner shall provide dependable and quiet ignition in the stages as called for.
- K. Gas burner controls shall provide automatic safety pilot, dual automatic gas valves, manual gas cock, and pressure regulator. Ignition shall be electric for the intermittent pilot with 100% shutoff when the unit is off.
- L. Induced draft blower shall provide pre-purge and shall be provided with a proving switch to prevent burner operation if venter is not in operation.
- M. Provide fan switch and limit control to delay the fan until heat is available and to continue fan operation until heat is dispersed. Limit switch shall shut the burner down in case of failure of operating controls.

## 2.2 ACCESSORY EQUIPMENT

- A. Unit shall be provided with hot gas reheat option for dehumidification. Hot gas reheat coil shall be located on the leaving air side of the evaporator coil and fully piped and circuited at the factory.
- B. Condenser coil hail guards shall be provided.

- C. A prefabricated heavy gauge galvanized steel, mounting curb shall be provided for field assembly on the roof decking prior to unit shipment. The roof curb shall be a full perimeter type with complete perimeter support of the air handling section and condensing section. The curb shall be a minimum of 14" high and include a nominal 2" x 4" wood nailing strip. Gasket shall be provided for field mounting between the unit base and roof curb.
- D. Provide economizer dampers and controls to provide "free cooling" from 0 to 100% outdoor air (OA) when the outside air humidity and temperature are acceptable. Provide OA, return air, and relief air dampers in a factory-provided enclosure. All air shall be filtered and bird screen shall be installed. A solid state enthalpy changeover control shall determine the capability of the outside air to provide free cooling. The control package shall include a differential enthalpy sensor in the return air duct to compare the enthalpy of the outside air and return air and use the air with the lowest enthalpy for free cooling or assisting the mechanical cooling. The cooling control sequence is as follows:
  - 1. The changeover control determines if the outdoor air is suitable for free cooling.
  - 2. The space thermostat determines if cooling is needed in the building. If so,
  - 3. The actuator modulates the outdoor air and return air dampers to maintain the desired mixed air temperature.
  - 4. The second cooling stage of the space thermostat energizes the compressor to assist the economizer if required.
  - 5. If the outdoor air is not suitable for free cooling, the outdoor air damper remains in the minimum ventilation position and the compressor is energized when space cooling is required.
- E. Provide a warm-up thermostat to prevent the OA dampers from opening if the return air temperature is below the set point (65 deg. F) (18 deg. C).
- F. Provide necessary controls for operation of the compressor below the normal temperature of the compressor cutout. Operation shall be permitted down to temperature specified on Drawings.
- G. Provide factory-trained service person to check out the system, calibrate the controls, and see that the RTU is operating properly. The service person making the settings shall make a written report to the Engineer and the Owner with all set points listed for future reference.
- H. Rooftop units mounted on slabs or other fixed locations shall be provided with adapters for end discharge and return to the unit.
- I. Provide programmable combination thermostat/humidistat and other controls required to produce the control functions called for.
- J. Manufacturer shall provide BACnet interface card for communication with EMCS.

## 2.3 ACCEPTABLE MANUFACTURERS

- A. Roof top unit shall be the make and model number shown on the schedule on the Drawings, or acceptable equivalents by Carrier, Lennox, Trane, York, or Daikin.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install the curb as required by the job conditions and as recommended by the manufacturer, and install proper flashing and counterflashing. See details on the Drawings.
- B. Set the unit in place, taking care to protect the adjacent roofing, and connect the supply and return ductwork.
- C. Make electrical and gas line connections, taking care that these do not block access to any part of the equipment requiring service.
- D. Have the factory service person check out the unit and make a written report. Place the unit in service.
- E. Connect full size condensate drain pipe to roof top unit and extend to nearest drain. Pipe shall be schedule 40 galvanized with malleable iron screwed fittings.

### 3.2 BALANCING AND TEST

- A. Operate the roof top unit and check for proper supply air quantity, noise, and proper operation.
- B. Report the airflow, static pressure, voltage and current draw of each item, refrigerant pressure readings, etc., as required by Section 23 05 93 – Testing, Adjusting, and Balancing. This system is not complete until these readings have been made, submitted to the engineer, and accepted.

**END OF SECTION**

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