

# PROJECT MANUAL

Remodel for Rice 360 Institute  
BioScience Research Collaborative (BRC)

RICE UNIVERSITY



Issued for TDLR Review, COH Permitting & Bidding  
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CH+P Project # 18-009

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## SECTION 230500 – BASIC MECHANICAL MATERIALS AND METHODS

### PART 1 – GENERAL

#### 1.01 PROVISIONS INCLUDED

- A. Include General Conditions, Supplementary General Conditions Division 0 and applicable parts of Division 01 for conditions and requirements which may affect the work of this Section.
- B. Examine all other Sections of the specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other Trades affecting, or affected by work of this Section. Cooperate with such Trades to ensure the steady progress of all work under the Contract.

#### 1.02 DEFINITIONS

- A. Words in the singular shall also mean and include the plural, wherever the context so indicates and words in the plural shall mean the singular, wherever the context so indicates.
- B. Wherever the terms "shown on drawings" are used in the specifications, they shall mean "noted", "indicated", "scheduled", "detailed", or any other diagrammatic or written reference made on the drawings.
- C. Wherever the term "provide" is used in the specifications it will mean "furnish" and "install", "connect", "apply", "erect", "construct", or similar terms, unless otherwise indicated in the specifications.
- D. Wherever the term "material" is used in the specifications it will mean any product", "equipment", "device", "assembly", or "item" required under the Contract, as indicated by trade or brand name, manufacturer's name, standard specification reference or other description.
- E. The terms "approved", or "approval" shall mean the written approval of the Architect.
- F. The term "specification" shall mean all information contained in the bound or unbound volume, including all "Contract Documents" defined therein, except for the drawings.
- G. The terms "directed", "required", "permitted", "ordered", "designated", "prescribed" and similar words shall mean the direction, requirement, permission, order, designation or prescription of the Architect. The terms "approved", "acceptable", "satisfactory" and similar words shall mean approved by, acceptable or satisfactory to the Architect. The terms "necessary", "reasonable", "proper", "correct" and similar words shall mean necessary, reasonable, proper or correct in the judgment of the Architect.
- H. "Piping" includes in addition to pipe or mains, all fittings, flanges, unions, valves, strainers, drains, hangers and other accessories relative to such piping.
- I. "Concealed" means hidden from sight in chases, furred spaces, shafts, hung ceilings, embedded in construction or in crawl spaces.
- J. "Exposed" means not installed underground or "concealed" as defined above.

- K. "Invert Elevation" means the elevation of the inside bottom of the pipe.
- L. "HVAC, Plumbing, and/or Fire Protection Contractor" shall refer to the Contractor or his Subcontractors responsible for furnishing and installation of all work indicated on the HVAC, Plumbing, and/or Fire Protection drawings and specifications, as applicable and or referenced to each Trade in the Architectural and/or Structural documents.
- M. "Mechanical Contractor" shall refer to the Fire Protection, Plumbing, HVAC and ATC Contractors, as applicable.
- N. "Architect" shall refer to the Architect "Courtney Harper Partners Architecture+Planning+Interiors" and/or Engineer "Bard, Rao + Athanas Consulting Engineers, LLC" and/or Owner.
- O. "Owner" shall refer to the designated representatives of the Project Owner.
- P. "General Contractor" shall refer to the Contractor(s) performing work under other sections of the Contract Specifications.
- Q. "Construction Manager" shall refer to the Construction Manager (CM) for project, as designated by the Owner.
- R. "Commissioning Agent (CA)" shall refer to the party employed by the Owner to witness the demonstration of all systems according to the commissioning plan. Refer to Division 01.

#### 1.03 CODES, STANDARDS AND REFERENCES

- A. All materials and workmanship shall comply with all applicable Codes, Specifications, Local and State Ordinances, Industry Standards and Utility Company Regulations, latest editions.
- B. In case of difference between Building Codes, State Laws, Local Ordinances, Industry Standards and Utility Company Regulations and the Contract Documents, the Mechanical Contractor, as applicable, shall promptly notify the Architect in writing of any such difference.
- C. In case of conflict between the Contract Documents and the requirements of any Code or Authorities having jurisdiction, the most stringent requirements of the aforementioned shall govern for budgetary purposes. However, no work will proceed until the Architect determines the correct method of installation.
- D. Should any Contractor, as applicable, perform any work that does not comply with the requirements of the applicable Building Codes, State Laws, Local Ordinances, Industry Standards and Utility Company Regulations, he shall bear all costs arising in correcting the deficiencies, as approved by the Architect.
- E. Applicable Codes and Standards shall include all State Laws, Local Ordinances, Utility Company Regulations and the applicable requirements of the following accepted Codes and Standards, without limiting the number, as follows:
  - 1. Codes
    - a. City of Houston Building Code
    - b. City of Houston Mechanical Code
    - c. City of Houston Fire Code
    - d. National Electrical Code
  - 2. Rice University Building Design Standards (November 2004)

3. Recommendations of the National Fire Protection Association (NFPA), latest applicable edition adopted, in general and in particular:
    - a. Life Safety, NFPA 101
    - b. HVAC, NFPA 90A, 90B
  4. Recommendations of ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers), including:
    - a. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
    - b. ANSI/ASHRAE 62-Ventilation for Acceptable Indoor Air Quality
    - c. ANSI/ASHRAE 55-Thermal Environmental Conditions for Human Occupancy
- F. In these specifications, references made to the following Industry Standards and Code Bodies are intended to indicate the accepted volume or publication of the Standard. All equipment, materials and details of installation shall comply with the requirements and latest revisions of the following Bodies, as applicable:
1. AMCA Air Moving and Conditioning Association
  2. ANSI American National Standards Institute
  3. ARI American Refrigeration Institute
  4. ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers
  5. ASME American Society of Mechanical Engineers
  6. ASTM American Society of Testing Materials
  7. AWS American Welding Society
  8. CS Commercial Standards, U.S. Department of Commerce
  9. FM Factory Mutual
  10. FS Federal Specification, U.S. Government
  11. MSS Manufacturers Standardization Society of the Valve and Fittings Industry
  12. NEMA National Electrical Manufacturers Association
  13. SMACNA Sheet Metal and Air Conditioning Contractor's National Association
  14. UL Underwriters' Laboratories, Inc.
- G. Contractor for the work under his charge, shall give all necessary notices, obtain and pay for all permits, pay all governmental taxes, fees and other costs in connection with his work; file for necessary approvals with the jurisdiction under which the work is to be performed. Contractor shall obtain all required Certificates of Inspection for his work and deliver same to the Architect before request for acceptance of his portion of work and before final payment is made.
- H. All equipment shall be installed per manufacturer's recommendations and requirements. The Contractor shall notify the engineer in writing when they intend to deviate from manufacturer's installation guidelines. The engineer shall advise if the installation is acceptable prior to installation.
- 1.04 SUBMITTALS
- A. Submit detailed shop drawings or brochures for approval of equipment and material proposed to be used on this project. Furnish the number of copies required by General Conditions.
  - B. Documents submitted shall show the following:
    1. Principal dimensions and details of construction.
    2. Operating and maintenance clearances.
    3. Weights of principal parts and total weights with information required for the design of supports and foundations.
    4. Sizes and location of piping and connections.

5. Performance data, including pump and fan curves; sound data including sound power dB levels in 1/3 octave bands.
  6. Data on electric motors, including brake horsepower of driven equipment, nameplate ratings and classes, sound data, starting and running full load currents, required starter size and recommended overload heater ratings.
  7. Approval stamp of Underwriters' and other authorities having jurisdiction of Contract Drawings requiring such approval.
  8. Certified performance guarantees.
  9. Minimum scale for sheet metal plans and piping plans shall be ¼ inch equal 1 foot.
- C. Submit brochures that contain only that information which is relative to the particular equipment or materials to be furnished. Do not submit catalogs that describe several different items other than those items to be used unless irrelevant information is marked out and relevant material is clearly marked.
- D. Specifications Compliance Statement
1. The manufacturer shall submit a point by point statement of compliance with the specifications.
  2. The statement of compliance shall consist of a list of all paragraphs (line by line).
  3. Where the proposed system complies fully, such shall be indicated by placing the word "comply" opposite the paragraph number.
  4. Where the proposed system does not comply, or accomplishes the stated function in a manner different from that described, a full description of the deviation shall be provided.
  5. Where a full description of a deviation is not provided, it shall be assumed that the proposed system does not comply with the paragraph in question.
  6. Submissions which do not include a point by point statement of compliance as specified shall be disqualified.

#### 1.05 GUARANTEE

- A. Attention is directed to provisions of the General Conditions and Supplementary General Conditions regarding guarantees and warranties for work under this Contract.
- B. Manufacturers shall provide their standard guarantees for work under this Contract, unless specified otherwise. However, such guarantees shall be in addition to and not in lieu of all other liabilities which the manufacturer and CM may have by Law or by other provisions of the Contract Documents. In any case, such guarantees and warranties shall commence when the Owner accepts the various systems, as applicable and as determined by the Architect. The guarantees and warranties will remain in effect for a minimum period of (1) year thereafter except where longer periods are specifically stated and specified.
- C. All materials, items of equipment and workmanship furnished under HVAC, shall carry the warranty against all defects in material and workmanship. Any fault due to defective or improper material, equipment, workmanship or design which may develop shall be made good, forthwith, by and at the expense of the Contractor responsible, including all other damage done to areas, materials and other systems resulting from this failure.
- D. Contractor shall guarantee that all elements of the systems provided under his Contract, are of sufficient capacity to meet the specified performance requirements as set forth herein or as indicated on the drawings.
- E. Upon receipt of notice from the Owner of failure of any part of the systems or equipment during the guarantee period, the affected part or parts shall be replaced by the responsible Contractor.



- F. Contractor shall furnish, before the final payment is made, a written guarantee covering the above requirements.

1.06 COMMISSIONING

- A. The TAB Contractor must also include sufficient man-hours within their bids, for their participation with the Commissioning Team and the rebalancing/readjusting/resetting all device setpoints, as required. For further definition, refer to the Commissioning Requirements of Division 01.

1.07 THE CONTRACTOR

- A. Contractor shall base his bid on site examinations performed by him. This requirement is mandatory. Contractor shall visit the proposed site where work is scheduled to be performed and ascertain for himself the amount of work required to fulfill the intent of his Contract and the complexity of the installation. Contractor shall not hold the Architect, his Consultants, agents or employees responsible for or bound by, any schedule, estimate or for any plan thereof. Contractor shall study all Contract Documents (HVAC, Plumbing, Fire Protection, Electrical, Communications, Architectural, Structural), etc., included under each Contract, to determine exactly the extent of work to be provided under each Section, and in installing new equipment and systems and coordinating the work with the other Trades and existing conditions.
- B. Contractor shall faithfully execute his work according to the terms and conditions of the Contract and specifications and shall take all responsibility for and bear all losses resulting to him in the execution of his work.
- C. Contractor shall be responsible for the location and performance of work provided under his Contract as indicated on the Contract Documents. All parties employed directly or indirectly by the Contractor shall perform their work according to all the conditions as set forth in these specifications.
- D. Contractor shall furnish all materials and perform all work in accordance with the project specifications and any supplementary documents provided by the Architect. The work shall include every item shown on the drawings and/or required by the specifications as interpreted by the Architect. All work and materials furnished and installed shall be new and of the best quality and workmanship. Contractor shall cooperate with the Architect so that no error or discrepancy in the Contract Documents shall cause defective materials to be used or poor workmanship to be performed.

1.08 COORDINATION OF WORK

- A. Contractor shall compare his drawings and specifications with those of other Trades and report any discrepancies between them to the Architect and obtain from the Architect written instructions for changes necessary in the mechanical or electrical work, to ensure that all work is installed in coordination and cooperation with other Trades installing interrelated work. Before installation, Contractor shall make proper provisions to avoid interferences in a manner approved by the Architect. All changes required in the work of Contractor caused by his negligence, shall be corrected by him at his own expense, to the Architect's satisfaction.
- B. Locations of piping, ductwork, conduits and equipment shall be adjusted to accommodate the new work with interferences anticipated and encountered during installation. Contractor shall determine the exact routing and location of his systems prior to fabrication or installation of any system component. Accurate measurements and coordination drawings will have to be completed to verify dimensions and characteristics of the various systems' installations.

- C. Lines which pitch shall have the right-of-way over those which do not pitch. For example, waste piping shall normally have the right-of-way. Lines whose elevations cannot be changed shall have the right-of-way over lines whose elevations can be changed.
- D. Offsets, transitions and changes of direction in all systems shall be made as required to maintain proper headroom and pitch of sloping lines whether or not indicated on the drawings. Contractor shall provide manual air vents and drains as required for his work to effect these offsets, transitions and changes in direction, as applicable.
- E. All work shall be installed in a way to permit removal (without damage to other parts) of coils, filters, control appurtenances, fan shafts and wheels, filters, belt guards, sheaves and drives and all other system components provided under this Contract requiring periodic replacement or maintenance. All piping shall be arranged in a manner to clear the openings of swinging overhead access doors, ceiling tiles and cleaning access doors in ductwork.
  - 1. Access to any and all components requiring servicing, adjustment, calibration, maintenance or periodic replacement shall be provided so that the Owner's operations personnel can freely gain access without removal of any materials other than the access panel or ceiling tile. Access shall be understood to mean free, clear and unobstructed from the floor up to the device and/or component being serviced. Access panels for VAV/CV boxes shall be 24" x 24" minimum.
  - 2. Fire rated access doors with closers shall be provided for all rated assemblies.
- F. The Contract Drawings are diagrammatic only intending to show general runs and locations of piping, ductwork, equipment, terminals and specialties and not necessarily showing all required offsets, details and accessories and equipment to be connected. All work shall be accurately laid out with other Trades to avoid conflicts and to obtain a neat and workmanlike installation which will afford maximum accessibility for operation, maintenance and headroom.
- G. Where discrepancies in scope of work as to what Trade provides items, such as starters, disconnects, flow switches, electric control components, etc., exist, such conflicts shall be reported to the Architect prior to signing of the Contract. If such action is not taken, the Contractor, as applicable, shall furnish such items as part of his work, for complete and operable systems and equipment, as determined by the Architect.
- H. Where drawing details, plans and/or specification requirements are in conflict and where pipe or duct sizes of same pipe or duct run are shown to be different between plans and/or between plans and sections or details, the most stringent requirement will be included in the Contract. HVAC systems and equipment called for in the specification and/or shown on the drawings shall be provided under this Contract as if it were required by both the drawings and specifications. However, prior to ordering or installation of any portion of work which appears to be in conflict, such work shall be brought to Architect's attention for direction as to what is to be provided.
- I. Final location of all air distribution devices, thermostats, heaters, control devices, sprinkler heads, etc., shall be coordinated with the Architectural reflected ceiling plans and/or other Architectural details, as applicable. (Note: Sprinkler head locations shall provide the specified coverage rating and water flow density, and shall be in accordance with all applicable Codes and in full compliance with the requirements of the Owner's insurance carrier.) Offsets of ductwork, added sheet metal, fittings, elbows, flexible connections, etc., shall be provided as required to comply with the Architectural reflected ceiling plans and/or installation details. Obtain approval of locations of all devices from Architect in the field, prior to installation.

- J. Laboratory equipment or other type of equipment shown on the Plumbing, Fire Protection, HVAC and/or Architectural drawings to be provided with services, such as exhaust ductwork, piping, traps, drains, valves, etc., shall be included under this Contract as applicable, including all piping or ductwork connections to systems, to make equipment completely operable. Additional sheet metal, flexible fittings, etc., shall be provided to accomplish the above requirement, as required, all as part of this Contract, at no additional cost to the Owner.

#### 1.09 COORDINATION DRAWINGS

- A. Before materials are purchased, fabricated or work is begun, Contractor shall prepare coordination drawings for all floors/areas, including buried systems/services (all-Trade-composite at 1/4" scale), showing the size and location of his equipment and lines, in the manner described herein under General Requirements.
- B. Coordination drawings are for the CM and Architect's use during construction and shall not be construed as shop drawings or as replacing any shop drawings. The coordination drawings, when corrected for actual "as-built" conditions, will be reviewed by the Architect, corrected and become the Record Drawings to be submitted to the Owner for his use.
- C. The cost of producing and reproducing the drawings will be included under the Contract of each Trade, including the cost or preparation of the Architectural building outlines. The HVAC Contractor shall take the lead to produce the Architectural backgrounds, show all ductwork, piping, etc., and circulate the drawings to any of his Subcontractors and the other Trades (Plumbing, Fire Protection, Electrical), so that they can indicate all their work as directed by the CM and Architect as required, to result in a fully coordinated installation.
- D. In addition to the regular coordination drawing review, the mechanical work will also be reviewed by the Architect to ensure that the system and equipment arrangements are suitable to provide maintenance access and service as follows:
  - 1. Valves and instrumentation should be grouped where possible and positioned in accessible locations.
  - 2. Valves on pipes of 6" and larger, positioned above 7'-0" in height from the operating level, will be provided with chain operated valve wheels and be located where chains will not interfere with primary access through the mechanical room.
  - 3. Location of control/diagnostic panels shall be shown and identified on the mechanical room coordination drawings.
- E. Prepare a complete set of computer-based 3-dimensional (3-D) coordinated drawings:
  - 1. Format shall be:
    - a. REVIT (Latest Version)
    - b. Other 3-D Modeling software as approved by the Architect.
  - 2. Scale not less than 1/4" scale equals 1'0", showing basic layout for the structure and other information as needed for preparation of Coordination Drawings.
  - 3. The drawings shall indicate the layout of all specialty trade work as indicated herein and shall be designated as Coordination Drawings.
  - 4. Any design drawing request to assist the Contractor will require:
    - a. A signed liability release form will be required from the Contractor prior to the release of files from the Engineer.
    - b. Two (2) weeks' notice for preparation of files.
- F. Highlight all fire rated partitions on the Coordination Drawings for appropriate coordination.
- G. The main paths for the installation or removal of equipment from mechanical and electrical rooms shall be clearly indicated on the Coordination Drawings.

- H. Each of the specialty trades shall add its work to the base drawings with appropriate elevations and grid dimensions. Specialty trade information shall be required for fan rooms and mechanical rooms, horizontal exits from duct shafts, crossovers and for spaces in the above ceilings where congestion of work may occur such as corridors and, where required, entire floors. Drawings shall indicate horizontal and vertical dimensions to avoid interference with structural framing, ceilings, partitions and other services. Indicate elevations relative to finish floor for bottom of ductwork and piping and conduit 6" greater in diameter.
1. Specialty Trade shall include:
    - a. Plumbing system.
    - b. HVAC piping and associated control systems.
    - c. Electrical.
    - d. Sheet Metal Work.
    - e. Fire Protection system.
    - f. Automatic Temperature Control
    - g. Fire Alarm
    - h. Security
    - i. Telecommunications
    - j. Commissioning
- I. Upon completing their portion of the Coordination Drawings, each specialty trade shall sign, date and return Coordination Drawings to the Contractor.
- J. Where conflicts occur with placement of materials of various trades, the General Contractor shall be responsible to coordinate the available space to accommodate all trades. Any resulting adjustments shall be initiated and dated by the affected specialty trade Subcontractor. The General Contractor shall then final date and sign each drawing.
- K. Fabrication shall not start until Coordinate Drawings have been distributed to all parties as indicated herein.
- L. Format: Coordination Drawings (plans only) shall be done using 3-D Modeling software. Files shall be given to the Architect for future transfer to Owner. Coordination Drawings will be used as base for as-built drawings.
- M. Distribution of Coordination Drawings:
  1. The General Contractor shall provide one print of each Coordination Drawing to:
    - a. Each specialty Contractor.
    - b. Owner.
    - c. Construction Manager.
    - d. Architect (for record purposes).
- N. After distribution:
  1. Resolve all interference's not previously identified.
- O. Coordination Drawings include but are not necessarily limited to:
  1. Structure.
  2. Partition/room layout, including indication of smoke and fire resistance rated partitions.
  3. Ceiling layout and heights.
  4. Light fixtures.
  5. Access panels.
  6. Sheet metal, heating coils, heat pumps, grilles, diffusers, etc.
  7. All heating piping and valves.
  8. Smoke and fire dampers.
  9. Soil, waste and vent piping.

10. Major water and gases.
11. Major electrical conduit runs, panelboards, feeder conduit and racks of branch conduit. Motor control centers, starters and disconnects.
12. Sprinkler piping and heads.
13. All equipment, including items in the Contract as well as O.F.C.I. and O.F.I. items.
14. Equipment located above finished ceiling requiring access for maintenance and service. In locations where acoustical lay-in ceilings occur indicate areas in which the required access area may be greater than the suspected grid systems.
15. Rainwater Piping.
16. Existing conditions, including, but not limited to, Mechanical, Plumbing, Fire Protection and Electrical items.

- P. The Architect's response to all requests for information (RFI's) generated by the trade contractors shall be distributed to all other affected trades as if this information was contained in the original contract documents. In other words, the party that issues an RFI is responsible for distributing the information to all affected parties.

#### 1.10 RECORD DRAWINGS

- A. Contractor shall maintain, current at the site, a set of Contract Drawings for his portion of the work on which he shall accurately show the actual installation of all work provided under his Contract indicating any variation from the Contract Drawings, in accordance with the General Conditions and Supplementary General Conditions. Changes whether resulting from formal change orders, requests for information, or other instructions issued by the Architect shall be recorded. Include changes in sizes, location and dimensions of piping, ducts, equipment, etc.
- B. Contractor shall indicate progress by coloring-in various pipes, ducts and associated appurtenances exactly as they are erected. This process shall incorporate both the changes noted above and all other deviations from the original drawings whether resulting from job conditions encountered or from any other causes.
- C. The marked-up and colored-up prints will be used as a guide for determining the progress of the work installed. They shall be inspected periodically by the Architect and Owner's representatives and they shall be corrected if found either inaccurate or incomplete. This procedure is mandatory. Marked up drawings shall include all flow diagrams, schedules, details and control diagrams.
- D. Contractor shall meet at a minimum on a monthly basis, with the Owner's representative to transfer the information from his HVAC, Plumbing, Fire Protection, etc., marked-up and colored-up prints to a set which will become the basis for preparation of as-built drawings.
- E. Upon completion of the project, the Contractor shall submit his marked-up drawings to the Architect for review and comment. After the Architect reviews and comments on this set of documents, the Contractor shall prepare as-built drawings using 3-D Modeling software. When the work is completed, the Contractor shall provide 2 hard copies to the Architect for submittal to the Owner and disks with all documentation and a set of reproducible drawing plots marked "As-Built" drawings. The Contractor shall bear all costs of producing the drawing files, providing all necessary drawing changes and printing the reproducible drawings for the work under his charge.

1.11 GIVING INFORMATION

- A. Contractor shall keep himself fully informed as to the shape, size and position of all openings required for his apparatus and shall give information to the Architect and other Contractors sufficiently in advance of the work so that all openings may be built in advance.
- B. The manufacturers listed within this specification have been preselected for use on this project. No submittal will be accepted from a manufacturer other than those specified. Should any Contractor wish to propose a substitution during the bid period, such request shall be made in writing to the Architect, at least (15) working days, prior to bid date. If substitutions are deemed acceptable, such items shall be issued as an Addendum, prior to bid due date.

1.12 EQUIPMENT AND MATERIALS

- A. Equipment and materials shall be delivered to the site and stored in original sealed containers, suitably sheltered from the elements, but readily accessible for inspection by the Architect until installed. All items subject to moisture damage such as controls, filters, etc., shall be stored in dry, heated spaces.
- B. Contractor shall have his equipment tightly covered and protected against dirt, water and chemical or mechanical injury and theft. At the completion of the work, equipment and materials shall be cleaned, polished thoroughly and turned over the Owner in a condition satisfactory to the Architect. Damage or defects developing before acceptance of the work shall be made good at Contractor's expense as applicable.
- C. Contractor shall make necessary field measurements to ascertain space requirements, for equipment and connections to be provided under his Trade and shall furnish and install such sizes and shapes of equipment to allow for the final installation to conform to the drawings and specifications.
- D. Manufacturers' directions shall be followed completely in the delivery, storage, protection and installation of any equipment. Promptly notify the Architect in writing of any conflict between any requirements of the Contract Documents and the manufacturer's directions and obtain the Architect's written instructions before proceeding with the work. Should any Contractor perform any work that does not comply with the manufacturer's directions or written instructions from the Architect, he shall bear all costs arising in correcting any deficiencies that should arise.
- E. Contractor shall furnish and install all equipment, accessories, connections and incidental items necessary to fully complete the work under his Contract for use, occupancy and operation by the Owner.
- F. Where equipment of the acceptable manufacturers requires different arrangement or connections from those shown, it shall be the responsibility of the Contractor to install the equipment to operate properly and in harmony with the original intent of the drawings and specifications. When directed by the Architect, Contractor shall submit drawings showing the proposed installation. If the proposed installation is approved, Contractor shall make all necessary changes in all effected related work provided under other Sections including location of roughing-in connections by other Trades, electrical requirements, piping, supports, insulation, etc. All changes shall be made at no increase in the Contract amount or additional cost to the other Trades and/or Owner.

- G. All equipment and materials required for installation under these specifications shall be new and without blemish or defect. Equipment and materials shall be products which will meet with the acceptance of the Authorities having jurisdiction over the work and as specified hereinbefore. Where such acceptance is contingent upon having the products listed or labeled by FM, UL or other testing laboratories, the products shall be so listed or labeled. Where no specific indication as to the type or quality of material or equipment is indicated, a first class standard article shall be provided.
- H. All equipment of one type (such as valves, fans, air handling units [packaged or custom built], air terminals, heat pumps, plumbing fixtures, etc.), shall be the product of one manufacturer.
- I. Equipment prepurchased on behalf of the Owner or by the Owner himself, if assigned to any of the Contractors, shall be received, inspected, installed, etc., as if it was purchased by the Contractors as applicable. All guarantees, service contracts, etc., shall be the same as for all other equipment provided under this Contract.

#### 1.13 CUTTING AND PATCHING

- A. Contractor shall be responsible for all core drilling, as required for work under his Contract, but in no case shall he cut into any structural elements without the written approval of the Architect.
- B. All cutting, rough patching and finish patching, shall be provided under this Contract.
- C. All concrete and masonry equipment bases shall be provided under this Contract.

#### 1.14 USE OF PREMISES

- A. Contractor shall confine all of his apparatus, storage of materials and construction to the limits indicated on the drawings and directed by the Architect and he shall not encumber the premises with his materials.
- B. In storing materials within areas (structure or ground), or when used as a shop, Contractor shall consult with the Construction Manager and shall restrict his storage to space designated for such purposes. Contractor will be held responsible for repairs, patching or cleaning arising from any unauthorized use of premises.
- C. Notwithstanding any approvals or instructions which must be obtained by the Contractor from the Architect in connection with use of premises, the responsibility for the safe working conditions at the site shall remain the Contractor's. The Architect or Owner shall not be deemed to have any responsibility or liability in connection therewith.
- D. Air handling unit or cooling tower sections shall not be used for storage of materials. The Contractor will be responsible for securing, and maintaining the equipment clean. The above requirement is mandatory.

1.15 PROTECTION/CLEANLINESS

- A. All materials such as valves, fittings, piping, ductwork, plenums, grilles, registers, diffusers, etc., shall be properly protected from the accumulation of dirt, dust, debris or any other contaminants. All ductwork and piping openings shall be temporarily closed by the Contractor installing same, so to prevent obstruction and damage, as a minimum at the end of each working day or more often if required by job conditions. Contractor shall take precautions to protect his materials from damage and theft.
- B. Contractor shall furnish, place and maintain proper safety guards for the prevention of accidents that might be caused by the workmanship, materials, equipment or electrical systems provided under his Contract.

1.16 DAMAGE CORRECTION AND EXTRA WORK

- A. Contractor shall be held responsible and shall pay for all damages caused by his work to the new and existing building structures and new and existing equipment, piping, duct systems, etc., and all work and finishes installed under this Contract in the new or in existing building. Repair of such damage shall be done as herein before specified, at the expense of the Contractor and to the Architect's satisfaction.
- B. Contractor shall promptly correct all work provided under his Contract and rejected by the Architect as defective or as failing to conform to the Contract Documents whether observed before or after completion of work and whether or not fabricated, installed or completed. Contractor shall bear all costs of correcting such rejected work.
- C. No claim for extra work will be allowed unless it is authorized by the Architect in writing before commencement of the extra said work.

1.17 TOUCH-UP PAINTING

- A. Contractor shall thoroughly clean all equipment and systems provided under this Contract from rust, splatters and other foreign matter or discoloration, leaving every part of each system in an acceptable prime condition. Contractor, for the work under his Contract, shall refinish and restore to the original condition all equipment and piping which has sustained damage to the manufacturer's prime and finish coats of paint and/or enamel.

1.18 HOUSEKEEPING PADS

- A. Coordinate housekeeping pads for:
  - 1. All equipment indoors or outdoors
  - 2. All floor supports or braces
- B. Pads shall be a minimum of 4" above the finished floor.
- C. Pad shall be a minimum of 6" larger than the equipment, support or isolation base in all directions.



- 1.19 DUCT AND PIPE SLEEVES, PLATES AND ESCUTCHEONS, FIRESTOPPING AND SMOKEPROOFING
- A. Where piping and/or ductwork pass through masonry or concrete walls or drywall partitions or floors, Contractor shall provide and set individual sleeves for each pipe or duct and all other work under his charge, as necessary for passage of all pipes and/or ducts. Sleeves shall be of sufficient size to provide 1/2" air space around the pipe or duct passing through (including insulation where pipes or ducts are insulated). All openings shall be sealed, smokeproofed and made tight. Contractor shall be responsible for the exact location of sleeves provided under his Contract and shall coordinate all requirements for piping and ductwork sleeves.
  - B. Contractor, for work under his charge, shall determine the required inside diameter of each individual wall opening or sleeve before ordering, fabrication or installation.
  - C. Sleeves and inserts shall not be used in any portions of the building, where their use would impair the strength or construction features of the building. Elimination of sleeves must be approved by the Architect.
  - D. Provide chrome plated brass escutcheons with set screw for exposed piping, in all areas except in mechanical rooms. In this area use plain brass or cast iron escutcheons suitable for painting. All escutcheons shall be sized to fit the bare pipe or insulation in a snug and neat manner. They shall be of sufficient size to cover sleeved openings for the pipes and of sufficient depth to cover sleeves projecting above floors. Escutcheons shall be as manufactured by Beaton & Caldwell, Dearborn Brass, or Grinnell.
  - E. Pipe or duct sleeves shall be made of Schedule 40 pipe, 20 gauge galvanized steel or 16 gauge steel as follows:
    - 1. Sleeves on pipes passing through masonry or concrete construction shall be Schedule 40 pipe.
    - 2. Sleeves on ducts passing through concrete construction shall be 20 gauge steel unless required otherwise by item 4. below.
    - 3. Sleeves on pipes or ducts passing through fire rated partitions shall be 16 gauge steel.
    - 4. Sleeves on pipes or ducts passing through non-rated drywall construction shall be 20 gauge galvanized steel.
  - F. Pipe or duct sleeves shall be set as follows:
    - 1. Set sleeves 1" above finish floor, (except set sleeves, 6" above finish floor at penthouses or mechanical rooms and 6" above finished roof) and flush on each side of walls. Coordinate roof penetrations with roof Subcontractor.
    - 2. Sleeves shall be set securely in place before concrete is poured when placed in concrete construction.
    - 3. Provide sheet metal sleeves for all duct penetrations and cover with sheet metal plates all penetrations after ductwork has been installed through walls/floors.
  - G. Contractor shall fire stop, smoke stop, and/or acoustically seal the space between the sleeves provided under his Contract and piping or ductwork as applicable, as follows:
    - 1. See specification Section 078413 Penetration Firestopping.

- H. Except as otherwise specified, underground piping passing through exterior walls or foundation slabs on grade, shall have penetration closures of the modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening. Links shall be loosely assembled with bolts to form a continuous belt around the pipe and with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the rubber sealing elements to expand and provide an absolutely watertight seal between the pipe and wall, reducing chances of cathodic reaction between these members. Contractor for work under his charge shall determine the required inside diameter of each individual wall opening or sleeve before ordering, fabrication or installation. The inside diameter of the wall opening shall be sized to fit the pipe and ensure a watertight joint. Where applicable, when installing seals, take into account the pipe O.D. if non-standard due to coating or jacketing.

1.20 MISCELLANEOUS IRON AND STEEL

- A. Contractor shall provide all primary and secondary steel supports and hangers as shown on the drawings and/or as required to support equipment, ductwork, piping, exhaust fans, or any other materials provided under the work of this Section.
- B. The work of this Section of designing, furnishing and installing all miscellaneous metal work associated with the system, and related items as indicated on the drawings and/or as specified herein, and includes, but is not limited to the items listed herein below.
- C. The scope of work shall include:
1. Exhaust fan support platforms including ship ladders, steel grating for decking, cross-bracing and floor stands.
  2. Intermediate beams to hang ductwork and piping from the roof. All piping and ductwork must be hung from beam or supported from the floor. Provide supplemental steel for support of equipment.
  3. Support of ductwork and piping in shafts in addition to support provided by structure.
  4. Support of ductwork via floor stands as required.
  5. Heat exchanger support racks.
  6. Piping support in underground concrete trench and manholes.
  7. Pipe anchors in the building.
  8. Hangers, brackets, angel irons or rods required for the support and protection of HVAC, plumbing and fire protection equipment.
  9. Field prime painting of galvanized steel and field finish painting.
- D. Shop Drawings for General Miscellaneous Items
1. Submit Shop Drawings of all miscellaneous metal items to Architect for approval, showing sizes and thickness of all members, types of materials, methods of connection and assembly, complete dimensions, clearances, anchorage, relationship to surrounding work by other Trades, shop paint, and other pertinent details of fabrication and installation.
- E. Contractor shall engage the services of a Professional Engineer registered within the state wherein the project is located to prepare complete Design Drawings and structural design computations based on, and closely following, the design and details on the Drawings. The Design Drawings and structural design computations, with the Engineer's seal affixed thereto, shall be submitted to the Architect for review. The structural design computations shall provide a complete structural analysis, including anchors and fastening devices, and shall certify as to conformation to governing laws and codes.

These submittals, upon review, must be sufficient, when taken in conjunction with this Specification to provide the complete basis of the fabrication and erection.

- F. Samples
1. Submit duplicate samples of all materials to be furnished under this Section if, and in size and form, requested by Architect.
- G. Do not order materials or begin fabrication until Architect's approval of submittals has been obtained.
- H. In addition to the governing laws and codes, the following Specifications and Codes form a part of this Specification:
1. American Iron and Steel Institute applicable standards.
  2. American Institute of Steel Construction "Code of Standard Practice for Steel Buildings and Bridges" and "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings".
  3. American Welding Society Code: Standard Code for Arc and Gas Welding in Building Construction.
- I. All materials shall be new stock, free from defects impairing strength, durability or appearance and of best commercial quality for each intended purpose.
1. Unless other wise specifically called for, work of this Section shall be fabricated of structural steel conforming to ASTM Specification A36.
  2. Steel pipe shall be seamless steel pipe conforming to ASTM Specification A53, Schedule 40.
  3. Steel tubing shall be seamless steel tubing conforming to ASTM Specifications A500 to A501.
  4. Construction specialties such as slotted inserts, wedge inserts, etc., shall be as manufactured by Hohmann and Barnard, Gateway Erectors, Inc., Richmond Screw Anchor Co. or equal approved by Architect.
  5. Non-ferrous metals shall be as specified under descriptions of specific items, herein below.
- J. Provide all anchors, bolts, sockets, sleeves, and other parts required for securing each item of work of this Section to the construction, including furnishing to concrete workers all required insets and sleeves for use at concrete.
1. All exposed fastenings shall be of the same material and finish as the metal to which applied, unless otherwise noted.
  2. Welding rods shall conform to AWS Standards and the recommendation of the welding rod manufacturer.
  3. Shop primer for other ferrous surfaces shall be a high-quality, lead-free, rust-inhibitive primer, Tnemec No. 10-99 Metal Primer or equivalent by Devoe and Reynolds Co., Carboline or equal.
- K. Metal surfaces shall be clean and free from mill scale, flake, rust and rust pitting. Metal work shall be well formed and finished to required shape and size, true to details, with straight, sharp lines and angles and smooth surfaces. Curved work shall be true radii. Exposed sheared edges shall be eased.

- L. Weld all permanent connections. Welds shall be continuous on all exposed surfaces and where required for strength on concealed surfaces. Exposed welds shall be ground flush and smooth, with voids filled with metallic filling compound (metallic filling compound not permitted on surfaces to receive hot-dip galvanizing). Tack-welding will not be permitted unless specifically called for. Do not use screws or bolts where they can be avoided. Where used, heads shall be countersunk, screwed up tight, and threads nicked to prevent loosening.
- M. Fastenings shall be concealed where practicable. Thickness of metal and details of assembly and supports shall give ample strength and stiffness. Joints exposed to weather shall be formed to exclude water.
- N. Do all cutting, punching, drilling and tapping required for attachment of anchor bolts and other hardware and for attachment of work by other Trades. All such cutting, punching, drilling, etc., shall be done prior to hot-dip galvanizing of the various components.
- O. Live loads shall be not less than the minimum required by law. Where specific live load are not set forth in the laws and codes applicable to this work, and are not given on the Drawings or in this Specification, designs shall be such as to support the live loads which may normally be imposed without failure, without deflection of more than 1/360 of length of any member, and without permanent deformation, all with a factor of safety of not less than 2 1/2 to 1.
- P. Shop Painting
  - 1. All ungalvanized ferrous metals under this Section shall be given a shop coat of rust inhibitive primer of type specified above.
    - a. Immediately before shop painting, remove all rust, loose mill scale, dirt, weld flux, weld spatter, and other foreign material with wire brushes and/or steel scrapers. Power tool clean in accordance with SSPC SP-3 (Power Tool Cleaning). Remove all grease with oil by use of solvent recommended by paint manufacturer. Sandpaper exposed surfaces as required to produce smooth, even finishes.
    - b. Apply paint by spray process in strict accordance with manufacturer's printed instructions to uniform thickness(es) recommended by manufacturer. Apply thoroughly and evenly and work well into corners and joints taking care to avoid sags and runs.
    - c. Do not paint surfaces to be embedded in concrete, or to be welded in the field. After field welds are complete, grind smooth and flush, thoroughly clean and then apply specified primer over all unprimed in the field by brush roller.
    - d. After erection, sand smooth and retouch all portions of the shop coats chipped or damaged during erection, and coat all field welds and connections with primer equivalent to that used for the shop coat.
- Q. Installation
  - 1. All materials shall be carefully handled and stored under cover in manner to prevent deformation and damage to the materials and to shop finishes, and to prevent rusting and the accumulation of foreign matter on the metal work. All such work shall be repaired and cleaned prior to erection.
  - 2. Work shall be erected square, plumb and true, accurately fitted, and with the tight joints and intersections. All anchors, inserts and other members to be set in concrete or masonry shall be furnished loose by this Trade to be built-into concrete and masonry and by those Trades as the work progresses. Later cutting or drilling shall be avoided wherever possible.
  - 3. All metal work shall be rigidly braced and secured to surrounding construction, and shall be tight and free of rattle, vibration, or noticeable deflection after installed.

4. Where members, other than expansion bolts or inserts, are fastened into concrete, set such members in holes formed as specified below, and secure permanently in place by installation of proprietary-type expanding grout manufactured specifically for such purpose, used strictly in accordance with manufacturer's directions.
    - a. Holes to receive members shall be formed with galvanized sheetmetal sleeves, expanded polystyrene foam, or other approved method to provide at least 1/2 inch clearance around entire perimeter. At exposed applications, hold expanding grout back 1/2 inch from finish surface and fill voids with Portland cement grout to match color and texture of surrounding concrete surface.
  5. Electrolytic Isolation
    - a. Where dissimilar metals are to come into contact with one another, isolate by application of a heavy coating of bituminous paint on contact surfaces in addition to shop coat specified above. Do not permit the bituminous paint in any way to remain on surfaces to be exposed or to receive sealant.
- R. Description of Major Items
1. The items described below constitute the major part of the work of this Section, but are not intended or implied to cover each and every item that may be required to properly complete the work. Carefully review the Drawings to determine the full extent of the miscellaneous metal work required.
- S. Steel Ladders/Platforms
1. Fabricate and install interior steel ladder at fans, air handling units, filter racks and all equipment requiring service. Ladders shall have a safety cage as required by OSHA regulations.
  2. Except as may be otherwise indicated on the Drawings, ladder shall be minimum 16 inches wide, fabricated of minimum 3/8 inch by 2 1/2 inches hot rolled steel rails and minimum 3/4 inches outside diameter steel pipe rungs. Rungs shall be spaced 12 inches on center and shall be continuously welded to the rails. Provide a pair of steel clip angles or wall brackets at bottom and steel anchor plates or wall brackets at top, welded to the rails, as indicated.
  3. Exterior steel ladders shall be hot dip galvanized after fabrication as specified hereinbefore. Rungs are to have non-slip surfaces.
  4. All shall be OSHA and ANSI compliant.
- T. Gratings and Frames
1. Fabricated and install steel gratings and frames at fan platforms.
  2. Steel grating frames shall consist of a steel angle perimeter frame constructed of steel angles, at least 4 inches by 4 inches by 3/8 inches carried around perimeter with coped or mitered, full-welded corners. Perimeter frames shall be anchored with 7/16 inch minimum diameter expansion bolts or other suitable devices of adequate capacity, at corners, two (2) per beam end, and spaced not more than 2 feet on center around full perimeter.
  3. Steel Gratings shall be pressure-locked type, with bearing bars spaced 1 3/16 inch on center and cross-bars spaced 4 inches on center. Sizes of bars shall be as required by manufacturer's loading tables to limit deflection of any member across any span to 1/240th of the span at live load of 100 pounds per square foot. Gratings shall be as manufactured by Borden Metal Products, Co., Irving Subway Grating Co., Reliance Steel Products Co., approved by Architect.
  4. All (gratings and) frames shall be hot-dip galvanized after fabrication as specified hereinbefore.

U. Miscellaneous Items

1. Carefully review all Drawings for miscellaneous metal items required but not specifically listed above, such as miscellaneous steel clip angles, miscellaneous steel bracketing, and other miscellaneous metal items as indicated on the Drawings, reasonably implied therefrom, or reasonably necessary for the thorough completion of the work.
2. Provide rigid and secure anchorage of all components whether or not specifically described in complete detail on the Drawings.

- V. Piping supports shall be coordinated with the building structure and shall span between roof beams as required.

1.21 WATERPROOFING, FLASHING AND COUNTERFLASHING

- A. Unless specifically indicated otherwise on the drawings, the Contractor shall provide all counterflashing and waterproofing of all piping, ductwork and equipment provided by him, which pierce roofs, walls and other weatherbarrier surfaces. All work under this paragraph shall be coordinated with the CM.
- B. All work shall be performed in a workmanlike manner to ensure weatherproof installation. Any leaks developed due to Contractor's work shall be repaired at his expense, to the Architect's satisfaction.
- C. Pipes passing through slabs shall have the sleeve extended above floors as hereinbefore specified to retain any water and the space between the pipe and sleeve caulked waterproof fire stopping. The top and the bottom shall be sealed with monolastic caulking compound.
- D. All flashing required for ductwork and piping penetrations shall be provided by the CM.

1.22 ELECTRICAL WORK, MOTORS, MOTOR CONTROLLERS

- A. See Divisions 26, 27 and 28 for Electrical requirements.

1.23 IDENTIFICATION OF MATERIALS

- A. See Section 230553.

1.24 VALVE TAGS, NAMEPLATES AND CHARTS

- A. See Section 230553.

1.25 PARTS LIST AND INSTRUCTIONS FOR OPERATION AND MAINTENANCE

- A. Contractor shall thoroughly instruct the representative(s) of the Owner, to the complete satisfaction of the Architect, in the proper operation of all systems and equipment provided by him. Contractor shall make arrangements, via the CM as to whom the instructions are to be given in the operation of the basic and auxiliary systems and the periods of time in which they are to be given. The Architect shall be completely satisfied that the representative of the Owner has been thoroughly and completely instructed in the proper operation of all systems and equipment before final payment is made. If the Architect determines that complete and thorough instructions have not been given by the Contractor to the Owner's representative, then Contractor shall be directed by the Architect to provide whatever instructions are necessary until the intent of this paragraph of the specification has been complied with.

All time required for Owner's instruction to satisfy the above requirements shall be included in this Contract. No extra compensation for such instructions will be allowed.

- B. The Contractor shall submit to the Architect for approval, a total of (6) typed sets, bound neatly in loose-leaf binders, of all maintenance and operating instructions for the installation, operation, care and maintenance of all equipment and systems. All data and literature furnished shall be specific for the make and model of the equipment furnished. General non-specific catalog data will not be acceptable. Information shall indicate possible problems with equipment and suggested corrective action. The manuals shall be indexed for each type of equipment. Each section such as fans, valves, plumbing fixtures, hot water heaters, boilers, air handling units, etc., shall be clearly divided from the other sections. A sub-index for each section shall also be provided. The methodology of setting-up the manuals shall be submitted to the Architect and Owner for approval prior to final submission of manuals.
- C. The instructions shall contain information deemed necessary by the Architect and shall include, but not be limited to, the following:
1. Instructional classes on equipment and systems operation for Owner's representative and maintenance personnel, by engineering staff of each Contractor. Minimum of 48 hours of instruction for minimum of (6) people. Instruction shall include:
    - a. Explanation of manual and its use.
    - b. Summary description of the HVAC systems.
    - c. Purpose of systems.
  2. System
    - a. Detailed description of all systems.
    - b. Illustrations, schematics, block diagrams, catalog cuts and other exhibits.
  3. Operations
    - a. Complete detailed, step-by-step, sequential description of all phases of operation for all portions of the systems, including start-up, shutdown, adjusting and balancing. Include all posted instruction charts.
  4. Maintenance
    - a. Parts list and part numbers.
    - b. Maintenance, lubrication and replacement charts and manufacturer's recommendations for preventive maintenance, as applicable to his work.
    - c. Troubleshooting charts for systems and components.
    - d. Instructions for testing each type of part.
    - e. Recommended list of on-hand spare parts.
    - f. Complete calibration instructions for all parts and entire systems.
    - g. Instruction for charging, filling, draining and purging, as applicable.
    - h. General or miscellaneous maintenance notes.
  5. Manufacturer's Literature
    - a. Furnish complete listing for all parts required for models actually furnished.
    - b. Names, addresses and telephone numbers of manufacturers and suppliers.
    - c. Describe and operation of all models actually furnished.
    - d. Furnish all and only pertinent brochures, illustrations, drawings, cuts, bulletins, technical data, certified performance charts and other literature with the model actually furnished to be clearly and conspicuously identified.
    - e. Internal wiring diagrams and engineering data sheets for all items and/or equipment furnished under each Contract.
    - f. Guarantee and warranty data.
  6. Contractor shall furnish instructions for lubricating each piece of equipment installed by him. Instructions shall state type of lubricant, where and how frequently lubrication is required. Frame instructions under glass and hang in a location as directed by Architect.

1.26 MANUFACTURER'S REPRESENTATIVE AND COMMISSIONING OF SYSTEMS

- A. Contractor shall provide, at appropriate time or as directed by the Architect, the on-site services of a competent factory trained Engineer or authorized representative of particular manufacturer of equipment provided under his Contract, such as for the air handling units, automatic temperature controls, building automation system (BAS), fire pump, domestic hot water heaters, boilers, etc., provided under this Contract, to instruct the Owner, inspect, adjust and place in proper operating condition any item provided by him, as applicable.
- B. Contractor shall commission and set in operating condition all major equipment and systems, such as the condenser water, hot water and all air handling systems, etc., in the presence of the applicable equipment manufacturer's representatives, and the Owner and Architect's representatives. In no case will major systems and equipment be commissioned by any of the Contractor's forces alone, without the assistance or presence of the equipment manufacturers.
- C. A written report shall be issued by the particular equipment manufacturer and the Contractor summarizing the results of the commissioning and performance of each system for the Architect's record. No additional compensation will be allowed for any Contractor for such services.
- D. The Contractor shall prepare and submit to the Architect for acceptance, a schedule of anticipated system commissioning. No system shall be commissioned without prior acceptance of the schedule by the Architect and Owner. No systems shall be commissioned prior to submittal and acceptance of Operation and Maintenance Manuals.

1.27 CONNECTIONS TO EQUIPMENT

- A. Contractor shall provide all duct and/or pipe connections, condensate traps, drains, overflows, relief valves and vents, power connections, etc., to make equipment operable, as provided under other Sections of the specifications, as shown on the Architectural and/or each Trade's drawings and herein specified, including final connections to equipment to result in a complete system, fully operational. Coordinate location of all equipment with Architect. Obtain installation diagrams and methods of installation of all equipment from manufacturers. Follow instructions strictly. If additional information is required, obtain same from Architect. If equipment is indicated on the Architectural drawings, it shall also be construed and understood by the Contractor to be constructed as shown on the HVAC drawings and shall be fully serviced and connected at no extra cost to the Owner.

1.28 SMOKE DETECTION AND FIRE SAFETY SYSTEMS

- A. All duct or unit mounted smoke detectors shall be furnished and wired to the building fire alarm system by the Electrical Contractor. All smoke detectors required in units and ducts shall be installed in the field by the HVAC Contractor. Refer to the Contractor Coordination Matrix contained under item 33 of this section.
- B. All smoke dampers shall be furnished by the HVAC Contractor with electric actuators field wired by the Electrical Contractor. Dampers shall be field installed by the HVAC Contractor.
- C. The Electrical Contractor, when providing smoke detectors, shall include additional contacts, as required and coordinated with the ATC Contractor, to allow for other control functions, as specified hereinafter. Close coordination must be exercised to allow for the provision of contacts.



- D. All smoke detectors shall be installed as recommended by the smoke detection system manufacturer in sheet metal ducts or plenums to ensure that the sensing elements are effective and shall coordinate installation of smoke detectors with the Electrical Contractor and detector manufacturer.
- E. The HVAC Contractor shall provide access doors to make all such detection heads accessible, and shall provide bracing for smoke detection sampling tubes, as recommended by the detector manufacturer, to properly and securely support such tubes.
- F. If duct smoke detectors are required to be installed in ducts that are exposed to outside ambient conditions, they shall be installed in ventilated accessible weatherproof enclosures. See details on HVAC Drawings.

#### 1.29 ELECTRICAL ROOM REQUIREMENTS

- A. The Contractor shall not install any piping, ductwork or equipment in or through electrical rooms, transformer rooms, electrical closets, telephone rooms or elevator machine rooms, unless piping, ductwork or equipment is intended to serve these rooms. If any Contractor violates this requirement, he shall remove and/or relocate all items as required at his expense and to the satisfaction of the Architect.

#### 1.30 HOISTING EQUIPMENT AND MACHINERY

- A. All hoisting equipment and machinery required for the proper and expeditious prosecution and progress of the work under this Contract shall be furnished, installed, operated and maintained in safe condition by each Contractor for his material and/or equipment delivered to the designated hoisting area. All costs for hoisting operating services shall be borne by the Mechanical Contractor for all equipment and work under his charge.

#### 1.31 STAGING

- A. All staging, exterior and interior, required to be over 8'-0" in height shall be furnished and erected by each Contractor for work under his charge and maintained in safe condition by him for proper execution of his work.

#### 1.32 PHASING AND MAINTAINING EXISTING SERVICES

- A. During the execution of the work, required relocation of existing equipment and systems in the existing areas where new work and connections are scheduled to be made shall be performed by each Contractor as indicated on the drawings, as required by the job conditions and as determined by the CM in close cooperation with the Architect and Owner's designated representative to facilitate the installation of the new systems and completion of this Contract.
  - 1. Outages required for construction purposes shall be scheduled for the shortest practical periods of time, in coordination with the Owner's designated representative for specific, mutually agreeable periods of time after each of which the interruption shall cease and service shall be restored. This procedure shall be repeated to suit the Owner's working schedule as many times as required until all work is completed.
- B. Prior to any deactivation and relocation, capping, valving, tie-in or demolition work, consult the drawings and arrange a conference with the Architect and the Owner's representative in the field to inspect each of the items to be deactivated, removed or relocated. Care shall be taken to protect all equipment designated to be relocated and reused. Give notice to all parties, with a minimum of (5) working days in advance.

- C. All draining of existing systems, filling and venting required to remove and relocate existing piping systems shall be included and provided under this Contract as required to perform the various equipment or piping relocations or new tie-ins.
- D. The phasing of the work shall be performed in strict accordance with the CM construction schedule. The new systems will be installed and completely commissioned prior to occupancy. Coordinate requirements for temporary heat or rerouting of existing services as required to accomplish the construction schedule.

1.33 COMPONENT COORDINATION

- A. Specification of the following equipment Scope of Work can be found in accordance with the following matrix:

| Device                                 | Furnished By | Installed By | Power Wiring | Control Interlock | Fire Alarm Wiring |
|--|--------------|--------------|--------------|-------------------|-------------------|
| Duct Smoke Detectors                   | Electric     | HVAC         | Electric     | ATC               | Electric          |
| Fire Dampers                           | HVAC         | HVAC         | N/A          | N/A               | N/A               |
| Supply and Return Boxes                | HVAC         | HVAC         | See Note (2) | ATC               | N/A               |
| Supply and Return Box Damper Actuators | ATC          | HVAC         | ATC          | ATC               | ATC               |
| Box DDC Controller                     | ATC          | HVAC         | ATC          | ATC               | N/A               |
| Box and Reheat Coil Valves             | ATC          | HVAC         | N/A          | ATC               | N/A               |
| Box and Reheat Coil Valve Actuators    | ATC          | ATC          | N/A          | ATC               | N/A               |
| Supply Reheat Coil                     | HVAC         | HVAC         | N/A          | N/A               | N/A               |
| Control Panels                         | ATC          | ATC          | Electric     | ATC               | N/A               |
| Sheet Metal Dampers                    | HVAC         | HVAC         | N/A          | ATC               | N/A               |
| Sheet Metal Actuators                  | ATC          | ATC          | N/A          | ATC               | N/A               |
| Flow Measuring Stations                | ATC          | HVAC         | N/A          | ATC               | N/A               |
| DDC Panels                             | ATC          | ATC          | Electric     | ATC               | ATC               |
| Control Valves                         | ATC          | HVAC         | ATC          | ATC               | N/A               |

Notes:

1. The above table is for clarification only and may not include all requirements. Refer to the individual equipment, material, and system specifications for further definition.
2. For power by ATC, Electrical shall provide 120V power to junction boxes on each floor as specified in Electrical and as shown on the Electrical drawings. All 120V power and all low voltage wiring from the junction boxes to control panels, terminal box controllers, valve actuators, etc., shall be provided as specified in ATC. If the quantity of 120V circuits furnished by Electrical is inadequate for the requirements of ATC, the ATC Contractor shall be responsible to run the necessary additional circuits from the appropriate electric panel as identified by Electrical.

**PART 2 – PRODUCTS - NOT USED**

**PART 3 – EXECUTION - NOT USED**

**END OF SECTION 23 05 00**

## SECTION 230529 – HANGERS AND SUPPORTS

### PART 1 – GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

#### 1.02 WORK INCLUDED

- A. Furnish and install all hangers, supports and assemblies for all parts of the mechanical systems. This shall include all piping, ducts and equipment specified in this Division and as shown on the drawings
- B. All materials shall be new and manufactured for the specific purpose of supporting systems, equipment, pipes, ducts, conduits and accessories.
- C. Secure all permits and local/state approval for the components as specified and included under this Section.

#### 1.03 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.
- B. Refer to Section 230598 – Mechanical Vibration Controls for specified information related to and affecting this section.

#### 1.04 REFERENCES

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.
  - 1. Material standards shall be as specified or detailed hereinafter and as following:
  - 2. ASME B31.9 – Building Services Piping, The American Society of Mechanical Engineers.
  - 3. ASME B31.1 – power piping.
  - 4. ASHRAE Systems and Equipment Handbook.
  - 5. ASTM F 708 – Standard Practice for Design and Installation of Rigid Pipe Hangers.
  - 6. MSS SP-58 – Pipe Hangers and Supports – Materials, Design and Manufacture; Manufacturers Standardization Society of the Valve and Fittings Industry.
  - 7. MSS SP-69 – Pipe Hangers and Supports – Selection and Application; Manufacturers Standardization Society of the Valve Fittings Industry.
  - 8. MSS SP-89 – Pipe Hangers and Supports – Fabrication and Installation Practices; Manufacturers Standardization Society of the Valve and Fittings Industry.
  - 9. NFPA-13 – Installation of Sprinkler Systems
  - 10. MSS-SP-127-2001 – Bracing for Piping Systems.

#### 1.05 SYSTEM DESCRIPTION

- A. In addition to special hangers and supports specified elsewhere in this Section and shown on the drawings for ducts, piping and equipment, furnish and install safe and substantial means of support for all parts of the mechanical systems. Shop drawings shall be submitted for review and approval for all supports. All piping, and ductwork, hangers and supports in all mechanical rooms and, penthouses shall be installed with vibration isolators. This requirement is mandatory and shall be strictly enforced.
- B. All piping shall be hung to true alignment, using appropriate and substantial hanger arrangements. Wire and strap hangers will not be permitted. Hangers shall be located so that piping and hangers will be clear of other piping, hangers, conduits, lighting and other obstructions.
- C. The hanging and supporting of piping and equipment shall conform to recommendations of the manufacturers of same and American National Standard, ANSI/MSS SP-58 and SP-69 latest edition, except where requirements of this specification exceed the above referenced Standards.

#### 1.06 SUBMITTALS

- A. See Section 230500 and General Conditions for Additional Requirements.
- B. All brackets and hangers shall be submitted for review. Include the method of hanging and supporting all piping, ductwork and equipment.
- C. The Architect is to be notified when the first bracket is assembled so that the installation can be reviewed in the field.
- D. Provide location of all inserts to be used for hanging ductwork, piping and equipment and the weight of all components (including water weight).

#### 1.07 QUALITY ASSURANCE

- A. Manufacturer: Company specializing in manufacturing products of the type specified in Part 2 – Products.
- B. Installer: Company specializing in performing work of the type specified in this section, with documented experience.
- C. Welders: Certify in accordance with ASME.

#### 1.08 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 code for installation of piping system and supports.
- B. Conform to ASME B31.1 code for power piping.
- C. All applicable codes.
- D. ASTM F708 for design and installation of pipe hangers..

- E. Welding Materials and Procedures: Conform to ASME (BPV IX) and applicable state labor regulations
  - 1. Provide certificate of compliance from authority having jurisdiction, indicating approval of welders.

1.09 DELIVERY, STORAGE AND HANDLING

- A. All hangers and supports shall be delivered in containers and shall be kept in a dry and protected area.
- B. All exposed hangers, supports, etc. shall be given 2 coats of rust resistant paint of a color selected by the Architect prior to installation.

1.10 ENVIRONMENTAL

- A. Do not paint or install inserts, hangers and/or supports when environmental conditions are outside the specific limitations of the referenced codes and manufacturer's recommendations.

**PART 2 – PRODUCTS**

2.01 GENERAL

- B. Pipe supports shall be of type and figure number as specified.
- C. Acceptable manufacturers subject to compliance with the specifications shall be as follows:
  - 1. Pipe Hangers
    - a. Carpenter & Patterson
    - b. B-Line
    - c. Grinnell
    - d. National Pipe Hanger Corp.
    - e. Piping Technology & Products Inc.
    - f. PHD Manufacturing, Inc.
  - 2. Constant Force Hangers.
    - a. Anvill International, Inc.
    - b. Piping Technology & Products Inc.
    - c. Piping Accessories, Inc.
    - d. Rilco Manufacturing Co.
    - e. PHD Manufacturing, Inc.
  - 3. Channel Support Systems
    - a. B-Line Systems, Inc.
    - b. Grinnell Corp. Power-Strut Unit
    - c. GS Metals Corp.
    - d. Michigan Hanger Co., Inc. O-Strut Div.
    - e. National Pipe Hanger Corp.
    - f. Thomas & Betts Corp.
    - g. Unistrut Corp.
    - h. Wesanco, Inc.
  - 4. Thermal-Hanger Shield Inserts
    - a. Carpenter & Patterson, Inc.
    - b. Michigan Hanger Co., Inc.
    - c. PHS Industries, Inc.
    - d. Pipe Shields, Inc.
    - e. Rilco Manufacturing Co., Inc.
    - f. Value Engineered Products, Inc.

## 2.02 PIPE HANGERS

- A. Bracket assemblies for supporting piping are to be fabricated by welding and all irregular surfaces are to be smoothed up by grinding. Shop drawings shall be submitted for review for each type bracket. The Architect is to be notified when the first bracket is assembled so that installation can be reviewed in the field. Exposed hangers, supports and brackets are to be given (2) coats of rust resistant paint of the color as selected by the Architect. Additionally, provide for Architect's review, the following:
1. Location of all inserts to be used for hanging ductwork and piping where applicable and the weight of such pipe or equipment to be hung, including the weight of water, valves and insulation.
  2. Method of hanging and support of all piping, ducts and other equipment.
- B. All pipe supports shall be of type and arrangement as hereinafter specified. They shall be so arranged as to prevent excessive bending stresses between supports.
- C. All bracket clamp and rod sizes indicated in this specification are minimum sizes only. This Section shall be responsible for structural integrity of all supports. All structural hanging materials shall have a safety factor of (5) built in. Beam clamps shall be 2-sided steel clamps designed to firmly attach to the flange of the beam with the load directed downward on the centerline of the beam web. Beam clamps shall be similar to B-Line #B3055, or approved equal.
- D. Other forms of hangers and supports shall be used to accommodate special or unusual job conditions or conditions not covered herein, subject to the approval of the Architect. When special conditions require the use of concrete inserts which are not "built in", such inserts may be used in locations approved by the Architect and shall be Phillips "Red Head" or approved equal. Explosive powder studs or detonator assisted studs or anchors will not be permitted.
- E. All pipes shall be hung free of dependence on pipe sleeves for support.
- F. All auxiliary steel required for pipe, duct and equipment supports shall be furnished and installed by the Mechanical Contractor.
- G. Threaded pipe, chains, wire and perforated straps will not be accepted. No piping shall be supported from ductwork, conduit or other piping. All system components and equipment shall be independently supported. Distribute hangers on parallel piping to avoid overloading of structure.
- H. Roller type supports shall be used for pipes subject to axial movement (all hot water steam, condensate and any emergency generator exhaust). They shall be braced so that movement occurs in roller rather than support rods. This requirement shall apply to piping 2 1/2" and up.
- I. Hangers and supports used for systems exposed to weather shall be hot dipped galvanized in accordance with ASTM A153-73 or A123. Rods and nuts shall be electro-galvanized.
- J. All horizontal water, drain, waste, vent and rainwater piping shall be hung with clevis steel hangers similar to B-Line #B3100. Groups of pipes in the same horizontal plane and with the same pitch may be supported on B-Line #3160 gang hangers. Wall brackets similar to shall be B-Line #B3066 and #B3077.
- K. All pipes which are hung so that the centerline of the pipe is less than 10" below the point of suspension of the hanger rod and all hydronic hot water piping shall be supported on roller hangers similar to B-Line #B3110.

- L. Unless otherwise noted, maximum hydronic pipe hanger spacing shall not exceed the recommendations of the pipe manufacturer and the following:
1. For 1/2" copper and steel pipe: 5'-0" o.c.
  2. For pipe 3/4" to 1 1/2": 8'-0" o.c.
  3. For pipe 2" to 8": 10'-0" o.c.
  4. For pipes 10" and up: 15'-0" o.c.
  5. In addition, hangers shall be installed within 2'-0" of each change in direction and on each side of valves 3" in size and up.
- M. Hanger rods shall be of steel and not less in diameter than:
1. For pipe 2" and under: 3/8"
  2. For pipe 2 1/2" and 3": 1/2"
  3. For pipe 4" and 5": 5/8"
  4. For pipe 6": 3/4"
  5. For pipe 8", 10" and 12": 7/8"
  6. For pipe 14" and 16": 1"
  7. For pipe 18" and up: 1 1/4"
- N. Insulated steel piping 2 1/2" and up, except chilled water, shall be fitted with steel pipe covering protection saddles similar to B-Line #B3163 and of the same depth as the specified insulation. Saddles shall be tack welded to the pipe and filled with loose insulation. Standard length saddles may be cut in (2) equal sections for attachment to pipes 6" diameter and under.
- O. Insulated piping 2" and under, except chilled water, shall be fitted with 16 gauge steel covering protectors at each hanger location similar to B-Line #B3151.
- P. Chilled water piping shall be insulated with high density hydrous calcium silicate shields where hangers occur similar to #B3380CW. Special care shall be exercised to assure a continuous vapor barrier installation to protect the system and prevent sweating.
- Q. All vertical piping shall be supported with steel riser clamps similar to B-Line #B3773. Such clamps on copper tubing shall be applied over couplings only.
- R. All pipes suspended at an elbow shall be hung using plate lugs similar to Grinnell #HS.53 with forged steel clevis similar to B-Line #B3201.
- S. Spring hanger locations shall be provided as specified herein, under vibration isolation, and shall be Grinnell, pre-engineered to meet loads and movements in accordance with ANSI B.31.1.10, where applicable.
- T. Drop rods for hangers may be used wherever possible and shall be installed prior to slabs being poured. Drop rod details shall be submitted to the Architect and Engineer for review.

## 2.03 DUCT HANGERS

- A. See Specification 233100 Sheet Metal.

## 2.04 MISCELLANEOUS MATERIALS

- A. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- B. Structural Steel: ASTM A 36M, steel plates, shapes, and bars, black and galvanized.

- C. Grout: ASTM C 1107, Grade B, factory-mixed and packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.
  - 1. Characteristics: Post hardening and volume adjusting recommended for both interior and exterior applications.
  - 2. Properties: Nonstaining, noncorrosive and nongaseous
  - 3. Design Mix: 5000-psi, 28-day compressive strength.

### **PART 3 – EXECUTION**

#### **3.01 PREPARATION**

- A. All hangers, rod and supports shall receive two (2) coats of rust inhibitive paint.
- B. Provide inserts for placement in concrete formwork.
- C. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- D. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
- E. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

#### **3.02 INSTALLATION**

- A. Pipe Hangers and Supports.
  - 1. Install in accordance with ASME B31.9, ASTM F 708, or MSS SP-89 or NFPA-13.
  - 2. Support piping, ductwork and equipment as specified under Part 2.
  - 3. Install hangers to provide minimum ½ inch space between finished covering and adjacent work.
  - 4. Place hangers with 24 inches of each horizontal elbow and on each side of valves 3" in size and up.
  - 5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
  - 6. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
  - 7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
  - 8. Provide copper plated hangers and supports for copper piping or between hanger support and piping.
  - 9. Prime coat (2 coats rust inhibitive paint) exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
  - 10. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- B. Where pipe support members are welded to structural building framing, scrape, brush clean and apply two coats of zinc rich primer to welds.

#### **3.03 INSERTS**

- A. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.



- B. Set inserts in position in advance of concrete work. Provide reinforcement rod in concrete for inserts carrying pipe over 4 inch or ducts over 60 inches wide.
- C. Finish inserts, flush with slab surface.
- D. Inserts: Steel, slotted type, factory-painted.
  - 1. Single rod: Similar to Grinnell Figure 281.
  - 2. Multi-rod: Similar to Carpenter and Paterson 1480 Type 1.
  - 3. Clip form nails flush with inserts.
  - 4. Maximum load 75 percent of rating.

#### 3.04 SUPPORTS FROM BUILDING CONSTRUCTION

- A. Inserts, Beam Clamps, Steel Fishplates (in concrete fill only), Cantilever Brackets or Other Means.
- B. Submit for Review.
- C. Grouped Lines and Services
  - 1. Trapeze Hangers fabricated of Bolted Angles or Channels.
- D. Where Building Construction is Inadequate
  - 1. Provide Additional Framing.
  - 2. Submit for Review.

#### 3.05 EXPANSION DEVICES

- A. Expansion anchors: Similar to Hilti "Drop-In Anchor HDI" flush type.
- B. Drill concrete to receive required expansion cases on concrete fasteners.
- C. Install in shear only, not in tension.

#### 3.06 EQUIPMENT BASES AND SUPPORTS

- A. Provide rigid anchors for ducts and pipes immediately after vibration connections to equipment.
- B. Refer to Specification Section 15001 for additional information.
- C. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.
- D. Grouting: Place grout under supports for equipment and make smooth bearing surface.

#### 3.07 METAL FABRICATION

- A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.

- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding appearance and quality of welds, and methods used in correcting welding work, and with the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base-metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.
  - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

### 3.08 ADJUSTING

- A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

### 3.09 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

**END OF SECTION 23 05 29**

## **SECTION 230553 – MECHANICAL IDENTIFICATION**

### **PART 1 – GENERAL**

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

#### 1.02 WORK INCLUDED

- A. Furnish and install nameplates, valve tags, valve charts, stencils and pipe markers on all Mechanical equipment, piping and ductwork.
- B. Provide nameplates with the unit number and service designation on all mechanical equipment.
- C. Indicate all valve tag numbers on Record Drawings and submit framed under glass valve tag charts including valve service and location.
- D. Install color coded ceiling tacks in acoustical tile ceilings or color coded tape on ceiling grid to identify location of equipment, valves and dampers that require regular maintenance or are part of a life safety system (fire dampers, smoke dampers, sprinkler valves or main isolation valves).
- E. Provide manufactured pipe and ductwork identification stencils with flow arrows and service indicated. All backgrounds of the stencils shall be color coded with specific service designation
- F. Prepare valve charts and frame under glass. All valves and the tag numbers shall be shown on the Record As-Built Drawings.
- G. Provide valve computer data base to match chart.

#### 1.03 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

#### 1.04 REFERENCES

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.
- B. Material standards shall be as specified or detailed hereinafter and as follows:
  - 1. ASME A 13.1 – Scheme for Identification of Piping Systems; The American Society of Mechanical Engineers.

#### 1.05 SUBMITTALS

- A. See Section 230500 and General Conditions for additional requirements.

- B. Product Data: Submit product description including materials, attachment methods, color coding and lettering sizes.

#### 1.06 QUALITY ASSURANCE

- A. All materials, lettering and individual system color coding schemes shall be uniform and of one single manufacturer.
- B. No identification shall be installed until all systems are complete and insulated.
- C. All surfaces shall be cleaned.
- D. No nametag or identification shall break or penetrate a surface used as a vapor barrier.

#### 1.07 REGULATORY REQUIREMENTS

- A. Conform to all local/state and NFPA requirements for color-coding or painting of systems, piping or equipment related to Life Safety or Fire Protection.

#### 1.08 DELIVERY, STORAGE AND HANDLING

- A. All identification systems shall be stored in sealed containers in suitable locations to keep the containers and contents dry and clean.

#### 1.09 ENVIRONMENTAL REQUIREMENTS

- A. All surfaces shall be cleaned and dry before applying any form of identification or tagging.
- B. Consult with the manufacturer prior to installation for the proper tagging and identification procedure and materials to be used on exterior outdoor equipment.

### **PART 2 – PRODUCTS**

#### 2.01 GENERAL

- A. Acceptable manufactures contingent on compliance with the specification.
  - 1. Seton
  - 2. W. H. Brady Company
  - 3. Marning Services Incorporated

#### 2.02 PIPE IDENTIFICATION AND VALVE TAGS

- A. All piping, except that piping which is within inaccessible chases, shall be identified with semi-rigid plastic identification markers equal to Seton Setmark pipe markers.
  - 1. Direction of flow arrows is to be included on each marker.
  - 2. Each marker background shall be appropriately color coded with a clearly printed legend to identify the contents of the pipe in conformance with the “Scheme for the Identification of Piping Systems” (ASME A13.1-1981).
  - 3. Setmark snap-around markers shall be used for overall diameters up to 6” and strap-around markers shall be used above 6” overall diameters.
  - 4. Markers shall be located:
    - a. Adjacent to each valve

- b. At each branch
  - c. At each cap for future
  - d. At each riser takeoff,
  - e. At each pipe passage through wall (each side)
  - f. At each pipe passage at 20' – 0" intervals maximum.
5. Underground pipe markers:
- a. Provide detectable tape on all underground piping;
  - b. Labels shall be color coded and labeled the same as indoors.
- B. Valve tags
1. All valves shall be designated by distinguishing numbers and letters carefully coordinated with a valve chart.
  2. Valve tags shall be color coded 0.032" anodized aluminum tags, with engraved letters similar to Seton S Type 250-BL or approved equal.
    - a. HVAC tags shall be round 2" diameter, similar to Seton 15426.
    - b. Plumbing tags shall be square 2" x 2" similar to Seton 42769.
    - c. Fire Protection tags shall be square 2" x 2" similar to Seton 42769 RED.
    - d. Lettering shall be ¼" high for type service and ½" for valve number. Tag shall indicate service and valve number.
    - e. Each service shall be a different color.
  3. Tag shall be attached to valves with chain similar to Seton No 16 stainless steel jack chain.
  4. Whenever a valve is above a hung ceiling, the valve tag shall be located immediately above the hung ceiling.
- C. Furnish a minimum of two (2) typed valve lists
1. Each framed under glass or Plexiglas. Each chart shall be enclosed in an approved 0.015" thick plastic closure for permanent protection.
  2. Valve numbers shall correspond to those indicated on the Record Drawings and on the printed valve lists.
  3. The printed list shall include the valve number, location and purpose of each valve.
  4. It shall state other necessary information such as the required opening or closing of another valve when one valve is to be opened or closed.
  5. Printed framed valve lists shall be displayed in each Mechanical Room or in a location designated by the Owner.
- D. Valve data base.
1. Provide a valve data base for all valves to operate on the building computer.
  2. Every valve shall include:
    - a. Tag Number
    - b. Service (Hot water, Chilled water, Sprinkler, etc.)
    - c. Size
    - d. Operation
    - e. Location
    - f. Manufacture
    - g. Model number
    - h. Submittal reference

## 2.03 DUCTWORK IDENTIFICATION

- A. All ductwork (supply, return, exhaust, etc.) serving multiple spaces or floors shall be identified with directional flow arrows and unit identification numbers (AHU-1, EX-1, etc.) on the side of each duct (or bottom if abutting other systems or obstructions).

- B. All flow arrows and labels shall be similar to Seton Name Plate Company vinyl labels or stencil painted.
- C. All duct access doors.

#### 2.04 EQUIPMENT NAMEPLATES

- A. Equipment nameplates shall be 3" x 6" long, 0.02" aluminum with a black enamel background with engraved natural aluminum letters similar to Seton Style 2065-20. Nameplate shall have pressure sensitive taped backing.
- B. The nameplate shall contain the unit or equipment designation ("AHU" for air handling unit, "HP" for heat pump, "P" for circulating pump, etc.), unit number and area or system served.
- C. Nameplates for exterior equipment shall be applied with waterproof adhesive.

#### 2.05 CEILING TACKS OR TAPE

- A. Provide steel color coded 3/4 inch diameter ceiling tacks in acoustical tile ceilings or color coded tape applied to ceiling grid to locate equipment, valves or dampers that require regular maintenance or are part of a Life Safety System.
- B. The tacks or tapes shall be color codes as follows:
  - 1. Yellow – HVAC
  - 2. Red – Life Safety (fire dampers, sprinkler valves, etc.)
  - 3. Green - Plumbing Valves.
  - 4. Blue – Heating/Cooling Valves.

### **PART 3 – EXECUTION**

#### 3.01 PREPARATION

- A. All surfaces shall be cleaned and insulated (if applicable) prior to installing any identification.
- B. Exterior surfaces of outdoor equipment shall be dry and prepared to accept the specified identification.

#### 3.02 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion. Seal with clear lacquer.
- B. Install valve tags with chain.
- C. Install duct markers in accordance with manufacturer's instructions.
- D. Install plastic pipe markers in accordance with manufacturer's Instructions.
- E. Install plastic tape markers complete around pipe in accordance with manufacturer's instructions.

- F. Identify air handling units, pumps, boilers, domestic hot water heaters, fire pumps, heat transfer equipment tanks, water treatment devices, etc. with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- G. Identify control panels and major control components outside panels with plastic nameplates.
- H. Identify thermostats relating to air handling equipment serving multiple spaces.
- I. Identify valves in main and branch piping with valve tags.
- J. Tag automatic controls, instruments and relays. Key to control schematic.
- K. Identify piping, concealed or exposed, with pipe markers. Use tags on piping  $\frac{3}{4}$  inch diameter and smaller. Identify service, flow direction and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- L. Identify ductwork with plastic nameplates and flow arrows. Identify with air handling unit or fan identification number and area served. Locate identification at air handling unit or fan, at each side of penetration of structure or enclosure, and at each obstruction.

**END OF SECTION 23 05 53**

## **SECTION 230593 – TESTING, ADJUSTING AND BALANCING**

### **PART 1 - GENERAL**

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

#### 1.02 WORK INCLUDED

- A. Provide all labor, instruments and materials necessary to completely test, adjust and balance all HVAC systems and equipment installed under this contract.
- B. All instruments shall be newly calibrated for this specific project.

#### 1.03 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

#### 1.04 REFERENCES

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.
- B. Material standards shall be as specified or detailed hereinafter and as follows:
  - 1. AABC MN-1 – National Standard for Testing and Balancing Heating, Ventilating and Air Conditioning Systems.
  - 2. ASHRAE 111 – Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems.

#### 1.05 SYSTEM DESCRIPTION

- A. Provide under this contract the services of an independent test and balance firm that specializes in testing and balancing of HVAC systems. The following services shall be provided:
  - 1. Balance Plan Check and Review: Review the design documents prior to commencing balancing. Submit any noted questions or discrepancies in writing to the Architect.
  - 2. On-going job site inspections of equipment, controls and metering devices during construction to verify conformance with design specifications, manufacturer's installation instructions.
  - 3. Air System Balance
  - 4. Hydronic System Balance
  - 5. Control Systems Verification
  - 6. Special System Testing and Verification
    - a. Duct leakage testing
    - b. Sound and vibration testing
  - 7. System Performance Verification



1.06 SUBMITTALS

- A. See Section 15050 – Submittals, for submittal procedures.
- B. Submit name of testing, adjusting and balancing contractor for approval within 30 days after award of Contract.
- C. Field Reports: Indicate deficiencies in systems that would prevent proper testing, adjusting and balancing of systems and equipment to achieve specified performance.
  - 1. Submit under provisions of Section 01400 – Quality Control.
  - 2. Prior to commencing work, submit report forms or outlines indicating adjusting, balancing and equipment data required.
  - 3. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for inclusion in operating and maintenance manuals.
  - 4. Provide reports in letter size, 3 ring binder manual, complete with index page and indexing tabs with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets and indicating thermostat locations.
  - 5. Include detailed procedures, agenda, sample reports forms and copy of AABC National Project Performance Guaranty prior to commencing system balance.
  - 6. Test Reports: Indicate data on AABC MN-1 forms, forms prepared following ASHRAE 111, NEBB forms, or forms containing information indicated in Schedules.
  - 7. Include the following on the title page of each report.
    - a. Name of Testing, Adjusting and Balancing Agency.
    - b. Address of Testing, Adjusting and Balancing Agency.
    - c. Telephone number of Testing, Adjusting and Balancing Agency.
    - d. Project name.
    - e. Project location.
    - f. Project Architect.
    - g. Project Engineer.
    - h. Project Contractor.
    - i. Report date.
- D. Project Record Documents: Record actual locations of all water systems balancing valves and rough setting.

1.07 DEFINITIONS

- A. AABC: The Associated Air Balance Council is a non-profit association of independent, certified agencies specializing in testing and balancing HVAC systems.
- B. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers.
- C. HVAC: Heating, Ventilating and Air Conditioning.
- D. TAB: Testing, Adjusting and Balancing of HVAC Systems to meet design objectives and obtain optimum system performance.
- E. NEBB: National Environmental Balancing Bureau

- F. TBE: Test and Balance Engineer is an individual certified by AABC as having a degree in Engineering and (3) years of test and balance experience, or (5) years of background in the air conditioning field and (5) years continuous field experience in testing and balancing work. The TBE must also pass the AABC Test and Balance Engineer Certification Examination.

#### 1.08 AGENCY QUALIFICATIONS

- A. Testing and balancing agency shall be a member of AABC or NEBB with a minimum of five (5) years of documented experience.
- B. An AABC certified NEBB certified testing and balancing person shall be responsible for certification of the total work of this section.
- C. All work shall be performed in accordance with AABC National Standards. If these specifications set forth more stringent requirements than the AABC National Standards, the more stringent specifications shall prevail.

#### 1.09 QUALIFICATION SUBMITTALS

- A. Testing and Balancing Agency shall submit a company resume listing personnel and project experience in the field of air and hydronic system balancing.
- B. Testing and balancing agency shall submit an inventory and calibration data of all instruments and devices in possession of the balancing agency to enable the Owner or his representative to evaluate the balancing agency's performance capability.
- C. The testing and balancing agency shall submit to the Owner or the Owner's representative, upon acceptance of the contract, an AABC or NEBB "Quality Assurance Guaranty."
- D. Within (30) days after acceptance of the contract, the testing and balancing agency shall submit to the Design Engineer a working agenda which will include procedures for testing and balancing each type of air and water flow system. The Test and Balance Report format will also be submitted indicating data to be recorded.

#### 1.10 CONTRACT DOCUMENTS

- A. Within (30) days after selection of the test and balance agency, the Construction Manager shall provide the agency with the following:
  - 1. Construction Drawings
  - 2. Equipment Specifications
  - 3. Equipment Submittals
- B. The testing and balancing agency shall be provided the following as issued or received:
  - 1. Change Orders/Current Updated Construction Mechanical Drawings incorporating all revisions
  - 2. Equipment Manufacturer's Submittal Data
  - 3. Mechanical/Air Conditioning Contractor's Shop Drawings
  - 4. Temperature Control Drawings
  - 5. Project Schedule

1.11 NOTIFICATION AND SCHEDULING

- A. A prebalance conference shall be held prior to job start as scheduled by the Owner or Owner's representative. Attendees at the meeting shall include representatives of the test and balance agency, General Contractor, Mechanical Contractor, Control Contractor, Owner and Mechanical Engineer.
- B. The schedule for testing and balancing the HVAC system shall be established by the Owner or Owner's representative, in coordination with the testing and balancing agency on a critical path network.
- C. The testing and balancing agency is responsible for initiating this continuing coordination to determine schedule for final testing and balancing services.
- D. It will be necessary for the testing and balancing agency to perform its services in close coordination with the Mechanical Contractor, with all scheduling and deficiencies reported through the Owner or Owner's representative.
- E. Before testing and balancing commences, the testing and balancing agency shall receive notification, in writing, from the Mechanical Contractor that the system is operational, complete, and ready for balancing.
- F. A completed system exceeds physical installation: the Mechanical Contractor shall certify that all prime movers, fans, pumps, cooling towers, boilers, etc., are installed in good working order, and that full load performance has been preliminary tested.
- G. The Mechanical Contractor shall certify in writing, that all equipment has been checked, started, adjusted by the manufacturer, and operated for the specified period of time.

1.12 COORDINATION WITH OTHER TRADES

- A. To bring the HVAC system into a state of readiness for testing, adjusting and balancing, the Mechanical Contractor shall perform the following:
  - 1. Air Distribution Systems
    - a. Ensure that all splitters, extractors, volume, smoke and fire dampers are properly located and functional. Dampers serving requirements of smoke, minimum and maximum outside, return, relief, and exhaust air shall provide tight closure and full opening, with a smooth and free operation.
    - b. Verify that all supply, return, exhaust, and transfer grilles, registers and diffusers are installed and operational.
    - c. Ensure that air handling systems, units, heat pumps, makeup air units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc. are blanked and/or sealed to eliminate excessive bypass or leakage of air.
    - d. Ensure that all fans (supply, return, relief, and exhaust) are operating and free of vibration. All fans and drives shall be checked for proper fan rotation and belt tension. Overload protection shall be of proper size and rating. A record of motor current and voltage shall be made to verify that the motors do not exceed nameplate rating.
    - e. Make any necessary changes to the sheaves, belts, and dampers, as required by the testing and balancing agency, at no additional cost to Owner.
    - f. Install clean filters prior to testing.

2. Water Circulating Systems
  - a. Check all pumps to verify pump alignment and rotation.
  - b. Ensure that systems are clean, with the proper strainer screens installed for normal operation.
  - c. Check all pump motors for current and voltage, to ensure that motors do not exceed nameplate rating.
  - d. Provide overload protection of proper size and rating.
  - e. Ensure that all water circulating systems shall be clean, full and free of air, that expansion tanks are set for proper water level, and that all air vents are installed at high points of systems and are operating.
  - f. Check and set operating temperature of heat exchangers to design requirements.
- B. The Temperature Control Contractor shall perform the following:
  1. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water resets, and fire and freeze stats.
  2. Verify that all controlling instruments are calibrated and set for design operating conditions.
  3. Calibrate room thermostats after installation and before the thermostat control verification tests are performed. The test and balance agency shall verify the accuracy of final settings by taking temperature readings. The readings shall be in a typical conditioned space for each separately controlled zone.
  4. The Control Contractor shall allow sufficient time in the project to provide assistance and instruction to the testing and balancing agency in the proper use and setting of control components such as, but not limited to, computers, static pressure controllers or any other device that may need setpoints changed so that the testing and balancing work can be performed.
- C. The Mechanical Contractor, Temperature Control Contractor, and the suppliers of the HVAC equipment shall all cooperate with the testing and balancing agency to provide all necessary data on the design and proper application of the system components. In addition, they shall furnish all labor and materials required to eliminate any system deficiencies.
- D. In coordination with the General Contractor, the testing and balancing agency shall arrange for an area of ample size and convenient location for storage of tools, equipment, and other items as required.

## **PART 2 - PRODUCTS**

### **2.01 GENERAL**

- A. The Construction Manager shall procure the services of an independent Balancing and Testing Contractor who specializes in the balancing and testing of heating, ventilating and air conditioning systems to balance and adjust, all moving equipment and air distribution and exhaust systems and test all water systems and equipment, as herein specified. All work by the Balancing Contractor shall be done under direct supervision of a qualified heating and ventilating Engineer employed by the Balancing Contractor. Balancing Contractor shall submit credentials and be approved prior to any contract award.
- B. Balance and testing shall not begin until all HVAC systems have been completed and are in full working order, as determined by the Architect. Where construction is phased, the Testing and Balancing Contractor shall submit a plan of action which outlines how each phase will be balanced and how, when completed, the entire system will be verified to be tested and balanced. The Balancing Contractor shall coordinate his work with the HVAC and ATC

Contractors, shall place all heating, ventilating and air conditioning systems and equipment into full operation, and continue the operation of same during each working day of adjusting and balancing.

- C. The Balancing Contractor shall perform all tests as hereinafter specified, compile the test data, and submit five (5) copies of the complete test data to the Construction Manager for forwarding to the Architect for evaluation and approval.
- D. The Construction Manager shall award the test and balance contract to the approved agency at the beginning of construction of the project to allow the Balancing Contractor to schedule this work in cooperation with the HVAC Contractor, ATC Contractor and other Trades involved and comply with completion data and requirements, as well as provide a list of areas where special requirements for balancing devices (dampers, valves) might occur.
- E. The Balancing Contractor shall provide all testing instruments used for balancing air and water systems. Testing instruments shall have been calibrated within a period of six (6) months prior to balancing. Types, serial numbers and dates of calibration of all instruments shall be listed in the final air and water balance reports herein specified.
- F. The Architect's, Engineer's and Owner's designated representatives shall be notified minimum five (5) days in advance of proceeding with balancing work to allow time for the witnessing of the testing, balancing and adjusting.
- G. The Balancing Contractor shall provide all manpower, instruments, temporary connections and all other materials required to accomplish the balancing and testing as hereinafter specified. In the case of phased construction, the action plan shall include an explanation of all temporary facilities and their effect on the overall system.
- H. The Balancing Contractor shall balance cooling systems in the air conditioning season and heating systems in the heating season. **This requirement is mandatory.**
- I. In the event it becomes necessary for the Owner to balance the HVAC systems correctly, after the balancing is complete, the cost of this work will be back charged to the Balancing Contractor.

## 2.02 SCHEMATIC SYSTEM DRAWINGS

- A. Piping Systems
  - 1. The Balancing Contractor shall prepare schematic diagrammatic drawings for the following systems:
    - a. Chilled Water
    - b. Hot Water
  - 2. The drawings will be 1-line schematic representation of the systems as they are installed, indicating all major automatic control valves, strainers, pressure reducing valves, etc., as well as all water flow and energy meters.
  - 3. The diagrams shall indicate, in addition to the graphic representation requirements outlined above, all pressure drops (design conditions and actual conditions) of each valve, strainer, meter, etc., as well as all flows at each meter.
  - 4. The use of the Engineer's construction drawing diagrams can be utilized by the Balancing Contractor as the base of the diagrams required. However, the drawings will have to be updated by the Balancing Contractor for field modifications which may have occurred during construction.

- B. Ductwork Systems
1. The Balancing Contractor shall prepare schematic diagrammatic drawings for the following:
    - a. Supply air systems (all units)
    - b. Return air systems (all units)
    - c. All exhaust air systems including specialized exhaust systems
  2. The drawings will be 1-line airflow schematics emanating from the air handling equipment, through shafts, to the first major split of duct branches on each floor. The drawings will indicate the air quantities measured at these major branches, pressure drop and any other pertinent information deemed necessary by the Architect.
  3. In addition to the duct schematic drawings, the Balancing Contractor shall prepare individual schematic drawings for each air handling unit indicating the pressure drop of each component of the unit, including the discharge plenum and unit duct discharge and shall prepare composite schematic drawing of all "special pressure" rooms or spaces which shall show on one drawing, the supply, return and/or exhaust systems, flow rates (design and actual) and final offset pressure/CFM.
  4. Balance "special pressure" spaces to the minimum differential pressure as scheduled:
    - a. Pressurized Stairwells +0.10" Water Gauge
    - b. Others Positive +0.025" Water Gauge
    - c. Others Negative -0.025" Water Gauge
- C. The intent of the required documentation would be to clearly indicate the balancing and performance of the systems as they are installed. Furthermore, the above-required information will be utilized by the Owner for future renovation and/or alterations of the various systems. Therefore, the drawing content and presentation will be submitted to the Architect for review prior to actual commencement of the work. In the case of phased construction, the schematics shall indicate the limit of each phase and any temporary measures taken to obtain system performance.
- D. The drawings shall be produced on AutoCAD latest, and a disc and one (1) set of reproducible vellums shall be submitted to the Owner through the Architect, for his use. All costs associated with the production of the documents shall be included under the Balancing Contractor's contract.
- E. Test Code Drawings
1. Each report shall contain a single line drawing or drawings of the air distribution system with the fan system, applicable zoning, etc., indicated. Each and every outlet supply and return shall be indicated on this drawing by a number corresponding to the number of the outlet test sheet.
- 2.03 TEST FORMS USED BY BALANCING ENGINEERS AND TECHNICIANS SHALL BE SET UP TO INCLUDE THE FOLLOWING INFORMATION:
- A. Each sheet shall have the job name and address, the name of the Balancing Contractor, Owner, Architect and Engineer, the instruments used to perform the test, and the name of the test Technician, date and time of test, outside db/wb temperatures.
- B. All forms shall be submitted on a standard 8 1/2" by 11" good quality paper, bound together to form a complete report. All forms shall be submitted in typewritten form; handwritten forms are not acceptable. Cover of first sheet shall list the name of the job and the location of same. Copies of all forms shall be submitted to the Architect for review and acceptance prior to the work beginning.

- C. Diffuser, Grille, Register, Fume Hoods, and All Types of Air Terminal Test Sheets
1. Each sheet shall be arranged in columns and all final sheets shall show the following data:
    - a. Fan system.
    - b. Room number or area designation.
    - c. Outlet code number which shall correspond to code number.
    - d. Size of outlet - manufacturer's listed data.
    - e. Type of outlet per manufacturer's model designation.
    - f. Manufacturer of outlet.
    - g. Manufacturer's effective area for each size.
    - h. Schedule FPM and required CFM of each outlet, individually for heating and cooling.
    - i. Test resultant FPM and CFM of each outlet, individually for heating and cooling.
    - j. Testing, setting and report of CFM settings for each terminal box, including pressure drop at each setting (heating and cooling).
    - k. All rooms/spaces with ducted supply and return/exhaust are to have supply, return/exhaust quantities shown on the same sheet. All rooms are to have air quantities for supply, return/exhaust listed per individual room. Supply, return/exhaust readings shall be listed sequentially, with final CFM offset, or room pressure clearly identified.
  2. Each exhaust hood that is exhausted by ductwork shall be tested, adjusted and balanced in coordination with the hood manufacturer, ATC Contractor, HVAC Contractor and fume hood controls manufacturer. Verify manufacturer's procedures and schedule testing with the required contractors prior to proceeding. Submit and coordinate the proposed testing procedure with the Owner's representatives and engineer prior to proceeding. Testing of face velocity shall be performed using a multipoint thermal anemometer device that is professionally calibrated prior to testing. Face velocity shall be measured at a minimum of one (1) reading per each square foot of open sash. Readings shall be recorded individually and averaged over the entire openings.
    - a. Constant Volume Fume Hoods (With Fan)
      - 1) Test exhaust fan as described.
      - 2) Set the sash in full open position.
      - 3) Measure airflow CFM and face velocity across open sash per ASHRAE 110 and ANSI Z9.5.
      - 4) Reseave fan as required to achieve desired CFM exhaust.
    - b. Constant Volume Fume Hoods
      - 1) Set exhaust valve to desired exhaust rate (CFM).
      - 2) Set sash in full open (or normal operating) position.
      - 3) Measure airflow CFM and face velocity across open sash per ASHRAE 10 and ANSI Z9.5.
      - 4) Adjust exhaust valve setting to achieve desired CFM exhaust.
      - 5) Calibrate exhaust flow transducer reading to match measured exhaust CFM.
    - c. VAV Fume Hoods (With Individual Fan)
      - 1) Test exhaust fan as described in paragraph 5. at full flow and at minimum sash height.
      - 2) Set sash in full open, normal operating and minimum positions. (Normal operating position as selected by institution or designated by engineer.)
      - 3) Measure exhaust airflow CFM and face velocity across open sash per ASHRAE 110 and ANSI Z9.5 at all positions.
      - 4) Reseave fan as required at full capacity on VFD (60 Hz) to match full open exhaust flow rate.
      - 5) Verify and adjust fume hood controls in coordination with fume hood control manufacturer to maintain 100 FPM (adj.) face velocity at full open normal operating and minimum positions.

- d. VAV Fume Hoods (With Exhaust Valves)
  - 1) Procedures shall be as outlined in previous paragraph except the adjustment of the fan and VFD shall be deleted.
  - 2) Exhaust valves shall be set to desired maximum exhaust rate and minimum exhaust flow rate. Measure face velocity and reset flow as required.
  - 3) Exhaust flow readings via duct traverse shall be compared to output from airflow measuring device. Adjust output as required.
  - 4) Two position fume hoods (with 2-speed fan).
  - 5) Two position hoods (with exhaust valve control).
- D. Air Handling Equipment Test Sheets
  1. Each sheet shall contain two (2) columns, one (1) for specified conditions and one (1) for test conditions obtained. When units tested are variable air volume (VAV) data shall be submitted for maximum and minimum air flows.
  2. All final sheets shall list the following data:
    - a. System fan number.
    - b. Fan manufacturer and model number.
    - c. Fan curve.
    - d. Total CFM.
    - e. Return air, CFM.
    - f. Outside air, CFM.
    - g. Total static pressure.
    - h. Suction static pressure.
    - i. Discharge static pressure.
    - j. Motor manufacturer.
    - k. Motor size, voltage, phase and RPM.
    - l. Amperage nameplate rating.
    - m. Final operating amperage.
    - n. Fan RPM (supply).
    - o. Fan RPM (return).
    - p. Component pressure drop.
- E. Exhaust and Ventilating Fan Test Sheets
  1. Each sheet shall contain in two (2) columns, one (1) for specified conditions and one (1) for test conditions obtained. Variable volume systems data is to be submitted for both maximum and minimum air flows.
  2. All final sheets shall list the following data:
    - a. Exhaust fan system and exhaust fan number.
    - b. Fan manufacturer.
    - c. Fan curve.
    - d. Size and model.
    - e. Motor HP, voltage and phase.
    - f. Changes made or recommended.
    - g. Amperage nameplate rating.
    - h. Final operating amperage.
    - i. Fan RPM.
    - j. Total CFM.
    - k. Suction static, discharge static, total static.
- F. Temperature Test Sheets (As Applicable For Each Air Handling Unit)
  1. The temperature test sheets shall list both the specified conditions and the actual operating conditions in opposite columns. Items listed on this sheet shall be as follows:
    - a. Cooling Cycle: Chilled Water
      - 1) Entering air db and wb temperature.



- 2) Leaving air db and wb temperature.
    - 3) Outside air db and wb temperature.
    - 4) Chilled water supply temperature.
    - 5) Chilled water return temperature.
    - 6) Unit discharge temperature.
  - b. Heating Cycle: Hot Water/Steam
    - 1) Entering air db temperature.
    - 2) Leaving air db temperature.
    - 3) Entering and leaving coil water temperatures/entering steam pressure.
    - 4) Outside air db and wb temperatures.
    - 5) Unit discharge temperature.
- G. Pump Test Sheets
  1. For each pump the following data shall be listed:
    - a. Pump number and system name.
    - b. Pump manufacturer and model number.
    - c. Pump curve.
    - d. Motor HP and RPM.
    - e. Voltage - Nameplate, test.
    - f. Amperage - Nameplate, test.
    - g. GPM, rated, tested.
    - h. Pressure rise rated, test.
    - i. Inlet pressure, outlet pressure.
    - j. Inlet temperature.
    - k. Shut-off pressure.
- H. Coil and All Other Heating Element Test Sheets (Unit Heaters, Reheat Coils, Reheat Boxes, Cabinet Unit Heaters, Fan Coil Unit)
  1. For each element both the specified and test conditions shall be listed:
  2. Inlet water temperature (hot/chilled water).
  3. Inlet air temperature.
  4. Outlet water temperature (hot/chilled water).
  5. Outlet air temperature.
  6. Pressure drop through unit.
- I. Velocity and Pressure Test Sheets for Main and Branch Ducts
  1. Duct location or designation.
  2. Duct size.
  3. Number of velocity readings.
  4. Duct average velocity.
  5. Total CFM.
  6. Duct average static pressure.
- J. Calibration of air flow measurement stations in cooperation and in conjunction with ATC contractor, provide all necessary pitot tube traverses and/or other air measurements necessary to field verify the accuracy of all installed air flow measurement stations at all air handling units, exhaust air handling units, return fans and cuts. Calibration readings shall be taken at 100%, 75%, 50% of rated flow and a curve shall be prepared that indicates any deviation between air flow station readings and field readings at these floors.

### PART 3 - EXECUTION

#### 3.01 AIR SYSTEM BALANCING AND TESTING PROCEDURES

- A. The Balancing Contractor shall perform the following tests, and balance all systems in accordance with the following requirements after clean filters are installed in all filter banks before tests are performed:
1. Test and adjust blower RPM or blade pitch angle on vane axial fans to achieve design requirements.
    - a. Test and record motor full load ampere.
    - b. Make pitot tube transverse of main supply, return and exhaust air ducts to obtain design CFM at fans.
    - c. Test and report system static pressure, suction and discharge.
    - d. Test and adjust system for design CFM recirculated air.
    - e. Test and adjust system for design CFM outside air.
    - f. Test and record entering and leaving air temperatures (db-wb cooling and db heating).
    - g. Adjust all main supply, return and exhaust air ducts to proper design CFM.
    - h. Adjust all zones and branches to proper design CFM, supply, return and exhaust systems.
    - i. Test and adjust each diffuser, grille, register, and constant volume box to within  $\pm 5\%$  of design requirements.
    - j. Test and adjust all special pressure rooms to maintain pressure relationship indicated on the drawings and to the pressures specified herein. Note that air quantities on the drawing may have to be changed to satisfy the pressure relationship.
    - k. Identify and list size, type and manufacturer of diffusers, grilles, registers, and terminal volume boxes. Include information regarding coils where applicable.
    - l. Measure air quantities in main and branch ducts by traversing entire cross sectional area of duct with pitot tube. Ducts having velocities of 1000 feet per minute or more shall be measured with inclined manometers (draft gauge) or magnehelic gauges; ducts having velocities of less than 1000 per feet per minute shall be measured with micromanometers, hook gauges, or similar low pressure instruments. Openings in ducts for pitot tube insertion shall be sealed with snap-in plugs and covered with duct tape after air balance is complete. Diffuser, grille and register air quantities shall be determined by direct reading velocity meters in accordance with the manufacturer's recommendations.
    - m. Identify, adjust, balance and measure air quantities in all types of hoods or exhaust "trunks", where applicable. Identify systems by fan designation and room name.
    - n. Obtain design air quantities in main ducts by adjusting fans. Branch duct air quantities shall be adjusted by volume dampers. Dampers shall be permanently marked after air balance is complete to enable them to be restored to their correct position if disturbed at any time.
    - o. As part of this Contract, the Balancing Contractor shall change the pulleys, belts, and fixed sheaves to provide for permanent sheaves, pulleys and belts, based on the final balancing, in order to ensure proper air delivery of the various systems. The Balancing Contractor shall also make all necessary adjustments to vane axial fan blade pitch angle to achieve required airflow.
    - p. In cooperation with the ATC Contractor, determine the proper setpoint for all automatically operated dampers, air valves, static pressure sensors, inlet vane actuators, or other variable or controllable devices requiring coordination between Balancing Contractor and ATC Contractor.

The Balancing Contractor shall determine the lowest system static setpoint possible that will deliver the proper air quantities to all outlets at the maximum cooling condition, and will adjust the fan system to operate at its most economical setting to achieve this static setpoint. Fans will be adjusted to the most economical setting by adjusting the fan speed (or blade pitch angle) with any variable volume devices in their maximum or wide-open position. Final static pressure setpoints are to be recorded in the test and balance report and listed for each unit.

- q. Any dampers, safing of baffles required for final balancing, as determined by the Balancing Contractor the Architect, will be provided by the HVAC Contractor to ensure proper performance, at no extra cost to the Owner.

### 3.02 WATER SYSTEM BALANCING AND TESTING PROCEDURES

#### A. Preparation of the System for Water Testing and Balancing

1. The Balancing Engineer or Technician must prepare the water system for balancing in the following manner:
  - a. Open all valves to full position, including coil stop valves, return line balancing cocks and close all bypass valves, including system differential pressure bypass valve if applicable.
  - b. Remove, clean and/or replace all strainers.
  - c. Examine water in system to determine if it has been treated and is clean.
  - d. Check pump rotation, correct if necessary.
  - e. Check expansion tank to make sure it is not air bound and that the system is full of water.
  - f. Check all air vents at high points of water systems to make sure they are installed properly and are operating freely.
  - g. Make certain all air is removed from circulating system.
  - h. Check operation of differential automatic bypass valves, set valve in closed position.
  - i. Check and set operating temperature of systems to design requirements.
  - j. Complete air balancing must have been accomplished before water balance is begun.
  - k. Set all temperature controls so that all cooling coils are calling for full cooling and heating coils are calling for full heating.
  - l. Set hot and chilled water systems to proper GPM delivery.
  - m. Check leaving water temperature, return water temperature and pressure drop through all coils. Reset to correct design temperatures.
  - n. Balance each hot water coil, chilled water coil and all other heating elements.
  - o. After making adjustments to coils and other waterflow elements, reset settings at pumps, as required to obtain proper flows.
  - p. Determine system operating differential pressure and, in conjunction with the ATC Contractor, set any differential pressure valves for proper operation.
  - q. Upon completion of flow readings and coil adjustments, and after water balance is complete, permanently mark all balancing valves, cocks and flow meters so that they can be restored to their correct position if disturbed. Properly set memory stops on all balancing valves so equipped.
  - r. After the Balancing Contractor sets all waterflow balancing devices to proper design GPM, he shall mark the GPM flows on the piping schematic drawings.

- s. The Balancing Contractor shall determine the lowest possible differential pressure control point possible for all variable speed pumping systems and for all differential pressure bypass control valves. In systems that have both variable speed pumping controlled by differential pressure and a differential pressure bypass valve, the Balancing Contractor shall assure, in conjunction with the ATC Contractor, that a minimum of 3 psig difference in setpoints is maintained between the two control settings with the differential pressure setpoint for the variable speed pumping system being the lower of the two settings.

### 3.03 INSTALLED ELEMENT TEST PROCEDURES

- A. Element identification (location or number designation).
- B. Required temperature drop corrected for actual entering air and water conditions.
- C. Element adjusted until the required drop is obtained.

### 3.04 CONTROL SYSTEMS VERIFICATION

- A. Verify all control devices are properly connected.
- B. Verify all dampers, valves and other controlled devices are operated by the intended controller.
- C. Verify all dampers and valves are in the position indicated by the controller (open, closed, modulating).
- D. Verify the integrity of valves and dampers in terms of tightness of close off and full open positions.
- E. Check all valves are properly installed in the piping system in relation to direction of flow and location.
- F. Check calibration of all controllers.
- G. Verify the proper application of all normally open and normally closed valves.
- H. Check the location of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts or cold walls.
- I. Check the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media. Control Contractor will relocate as deemed necessary by the testing and balancing agency.
- J. Check the sequence of operation that any control mode is in accordance with approved shop drawings. Verify that only minimum simultaneous heating and cooling occurs. Observe that the control valves at the boiler/heat pump loop are properly sequenced.
- K. Verify all controller setpoints meet the design intent.
- L. Check all dampers for free travel.
- M. Verify the operation of all interlock systems.

- N. Perform all systems verification to ensure the safety of the system and its components.

### 3.05 SPECIAL SYSTEMS TESTING

#### A. Duct Leakage Testing

1. Testing shall be conducted before external insulation is applied and before ducts are connected.
2. Mechanical Contractor to close off and seal all openings in the duct section to be tested.
3. Each section shall be tested by the Mechanical Contractor in accordance to the leakage class as specified under Section 15890 and SMACNA Standards. All tests shall be witnessed and documented by the TAB Contractor.

#### B. Sound and Vibration Testing

##### 1. Sound

- a. Sound level readings shall be taken in at least (10) locations in the building with an octave band analyzer.
- b. The test data for each area will be recorded on noise criteria curves indicating the decibel level read in each frequency band, the NC level required, and the NC level measured.
- c. Readings shall be taken at night in order to reduce the ambient noise level.
- d. The testing and balancing agency will submit the test data and test equipment data to the Architect and Engineer for their review and include the approved forms in the testing and balancing report.

##### 2. Vibration

- a. Vibration field measurements shall be taken as required for each circulating water pump, cooling towers, air handling unit, and fan driven by a motor over 10 HP.
- b. Readings shall include shaft alignment, equipment vibration, bearing housing vibration, foundation vibration, and building structure vibration.
- c. Readings shall be made using portable equipment capable of filtering out unwanted frequencies.
- d. Maximum vibration at any point listed above shall not exceed criteria listed in the ASHRAE Handbook, HVAC Systems and Application, Chapter 52 "Sound and Vibration Control", Table 26 "Equipment Vibration Criteria", unless otherwise specified. Readings shall be taken with vibration isolation blocked solid to the foundation.

### 3.06 SYSTEM PERFORMANCE VERIFICATION

- A. At the time of final inspection, the test and balance agency shall recheck, in the presence of the Owner's representative, specific and random selections of data, air quantities, and air motion recorded in the Certified Report.
- B. Points and areas for recheck shall be selected by the Owner's representative.
- C. Measurement and test procedures shall be the same as approved for work forming basis of Certified Report.
- D. Selections for recheck, specific plus random, will not normally exceed 25% of the total number tabulated in the report, except that special air systems may require a complete recheck for safety reasons.

- E. If random tests elicit a measured flow deviation of 10% or more from that recorded in the Certified Report listings, by 10% or more of the selected recheck stations, the report is rejected, all systems shall be readjusted and tested, new data recorded, new Certified Report submitted, and new inspection tests made, all at no additional cost to Owner.
- F. Following system verification of the Certified Report by the Owner's representative, the settings of all valves, splitters, dampers, and other adjustment devices shall be permanently marked by the testing and balancing agency so that adjustment can be restored if disturbed at any time. Devices shall not be marked until after system verification.

### 3.07 RECORD AND REPORT DATA

- A. The test and balance report shall be complete with logs, data and records as required herein. All logs, data and records shall be typed on white bond paper and bound. The report shall be certified accurate and complete by the testing and balancing agency's certified balancing engineer.
- B. Six (6) copies of the test and balance report are required and shall be submitted to the Owner or the Owner's representative.
- C. The report shall contain the following general data in a format selected by the testing and balancing agency.
  - 1. Project number.
  - 2. Contract number.
  - 3. Project title.
  - 4. Project location.
  - 5. Project Architect.
  - 6. Project Mechanical Engineer.
  - 7. Test and Balance Agency.
  - 8. Balancing Engineer.
  - 9. General Contractor.
  - 10. Mechanical Contractor.
  - 11. Date tests were performed.
  - 12. Certification.
- D. The test and balance report shall be recorded on report forms conforming to the recommended forms in AABC National Standards. At a minimum, the report shall include:
  - 1. Preface: A general discussion of the system, any abnormalities and problems encountered.
  - 2. Instrumentation List: The list of instruments including type, model, manufacturer, serial number, and calibration dates.
  - 3. System Identification: In each report the supply, return and exhaust openings and traverse points shall be numbered and/or lettered to correspond to the numbers and letters used on the report data sheets.
  - 4. Air Handling Equipment (Heat Pumps, Makeup Air, Roof Top Units, etc.)
    - a. Manufacturer, model number, and serial number.
    - b. All design and manufacturer related data.
    - c. Total actual CFM by traverse if practical; if not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.
    - d. Suction and discharge static pressure of each fan, as applicable.
    - e. Outside air and return air total CFM.
    - f. Actual operating current, voltage, and brake horsepower of each fan motor.

- g. Final RPM of each fan.
  - h. Fan and motor sheave manufacturer, model, size, number of grooves, and center distance.
  - i. Belt size and quantity.
  - j. Static pressure controls final operating setpoints.
5. Pumps
- a. Manufacturer, size, and serial number.
  - b. All design and manufacturer's related data.
  - c. Pump operating suction and discharge pressure and final total dynamic head.
  - d. No flow (pump discharge valve closed) suction and discharge pressure and corresponding total dynamic head. This procedure is to determine actual impeller size.
  - e. Rated and actual operating current, voltage, and brake horsepower of each pump motor.
  - f. Submit pump curve showing design, operating, and no-flow points of operation.
6. Heat Exchangers
- a. Manufacturer and model number.
  - b. All design and manufacturer's related data.
  - c. Service and location.
  - d. Actual pressure drop and related GPM – condenser water side.
  - e. Actual pressure drop and related GPM – heat pump side.
  - f. Entering and leaving temperatures condenser water and heat pump water.
  - g. Temperature control setting.

**END OF SECTION 23 05 93**

## **SECTION 230598 – MECHANICAL VIBRATION CONTROL**

### **PART 1 – GENERAL**

#### **1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

#### **1.02 WORK INCLUDED**

- A. Furnish and install all necessary vibration isolation materials to eliminate excessive noise and vibration from all building mechanical systems.
- B. Secure all permits and local/state approval for the installation of all components included under this Section.
- C. The work in this Section shall include the following:
  - 1. Vibration isolation elements for equipment.
  - 2. Equipment isolation bases.
  - 3. Piping flexible connectors.

#### **1.03 RELATED SECTIONS**

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

#### **1.04 REFERENCES**

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.
- B. Material standards shall be as specified or detailed hereinafter and as follows:
  - 1. NEBB– Procedural Standards for Measuring Sound and Vibration; National Environmental Balancing Bureau.
  - 2. NEBB– Sound and Vibration in Environmental Systems; National Environmental Balancing Bureau.
  - 3. ASHRAE Guidelines – HVAC Applications; Chapter– Sound and Vibration Control.

#### **1.05 SUBMITTALS**

- A. See Section 230500 and General Conditions for additional requirements.
- B. The Vibration Isolation Submittal shall include descriptive data for all products and materials including the following:
  - 1. Product Descriptions
    - a. A complete description of products to be supplied, including product data, dimensions, specifications and installation instructions.



- b. An itemized list of isolated and non-isolated equipment. Detailed schedule and selection data for each vibration isolator supporting equipment, including:
    - 1) Equipment identification mark
    - 2) Isolator type
    - 3) Actual load
    - 4) Static deflection expected under actual load
    - 5) Specified minimum static deflection
    - 6) Additional deflection-to-solid under load
    - 7) Ratio of spring height under load to spring diameter
    - 8) Base type
  - c. Steel rails, steel base frames, and concrete inertia bases showing all steel work, reinforcing, vibration isolator mounting attachment method, and location of equipment attachment bolts.
- 2. Show equipment base construction for all equipment, including dimensions, structural member sizes and support point locations.
  - 3. Indicate isolation devices selected with complete dimensional and deflection data.
  - 4. Show all methods of suspension and support for ceiling hung equipment.
  - 5. Detail methods of isolation for ducts and pipes piercing walls and slabs.
  - 6. Provide special details necessary to convey complete understanding of the work to be performed.
- C. Submission of samples may be requested for each type of vibration isolation. After approval, samples will be returned for installation at the job if requested. All costs associated with submission of samples shall be borne by the Contractor.

#### 1.06 QUALITY ASSURANCE

- A. All vibration isolators shall have calibration markings or some method to determine the actual deflection under the imposed load after installation and adjustment.
- B. All isolators shall operate within the linear portion of their load versus deflection curves. Load versus deflection curves shall be furnished by the manufacturer and must be linear over a deflection range of at least 50% above the design deflection.
- C. The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than  $\pm 10\%$ , and shall be non-resonant with equipment forcing frequencies or support structure natural frequencies.
- D. All neoprene components shall have a shore hardness of 30 to 50  $\pm 5\%$ , after minimum aging of (20) days or equal oven aging.
- E. Substitution of internally isolated and restrained equipment in lieu of the isolation and restraints specified in this Section is acceptable provided all conditions of this Section are met. The equipment manufacturer shall provide a letter of guarantee stating that the specified noise and vibration levels will be obtained. All costs for converting to the specified external vibration isolation shall be borne by the equipment manufacturer/installing contractor should submissions or installations be found to be unacceptable pursuant to the intent of this specifications.
- F. Should any rotating equipment cause excessive noise or vibration, the Contractor shall be responsible for rebalancing, realignment, or other remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

- G. Upon completion of the work, the Architect or Architect's representative shall inspect the installation and shall inform the Installing Contractor of any further work that must be completed. Make all adjustments as directed by the Architect that result from the final inspection. This work shall be done before vibration isolation systems are accepted.
- H. Manufacturer Responsibility
  - 1. Manufacturer of vibration control equipment shall have the following responsibilities:
    - a. Determine vibration isolation sizes and locations.
    - b. Provide equipment vibration isolation as scheduled or specified.
    - c. Guarantee specified isolation system deflections.
    - d. Provide installation instructions, drawings and field supervision to ensure proper installation and performance of systems.
  - 2. Substitution of internally isolated mechanical equipment in lieu of the specified isolation of this Section must be approved for individual equipment units and is acceptable only if above acceleration loads are certified in writing by the equipment manufacturer and stamped and sealed by a licensed Civil or Structural Engineer.
  - 3. Licensed Engineers shall be licensed in the project state.

#### 1.07 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 code for installation of piping system and ASTM F708 for design and installation of pipe hangers.
- B. Welding Materials and Procedures: Conform to ASME (BPV IX) and applicable state labor regulations.
- C. Provide certificate of compliance from authority having jurisdiction, indicating approval of welders.

#### 1.08 DELIVERY, STORAGE AND HANDLING

- A. All vibration control equipment shall be delivered in containers and shall be kept in a dry and protected area.
- B. All exposed hangers, supports, etc. shall be given 2 coats of rust resistant paint of a color selected by the Architect prior to installation.

### **PART 2 – PRODUCTS**

#### 2.01 ISOLATORS AND RESTRAINTS – GENERAL

- A. Acceptable Manufacturers subject to compliance to specifications.
  - 1. Mason Industries (MI)
  - 2. Amber/Booth (AB)
  - 3. Kinetics Noise Control (KNC)
  - 4. Vibration Eliminator Co. (VEC)
  - 5. Vibration Mountings & Controls (VMC)
- B. The Mechanical Contractor shall provide necessary vibration isolation materials to eliminate excessive noise and vibration from being transmitted from HVAC equipment to the occupied areas within the building. This includes all non-structural components such as, but not limited to, air handlers, fans, pumps, tanks, ductwork, piping, etc. (hereinafter called equipment).

- C. Isolators and supports shall maintain the equipment in a captive position and not short circuit isolation during normal operating conditions. Isolators shall have provisions for bolting and/or welding to the structure.
- D. All metal parts of vibration isolation units installed out-of-doors shall be cold dip galvanized, cadmium plated, or neoprene or PVC coated after fabrication. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard #14.
- E. All base supported isolators shall have base plates with bolt holes for fastening the isolators to the support members.
- F. Isolator types are scheduled to establish minimum standards. At the Contractor's option, laborsaving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories must not degrade the vibration isolation system.
- G. Static deflection of isolators shall be as scheduled in this Section and as shown on the drawings. All static deflections stated are the minimum acceptable deflection under actual load. Isolators shall be selected for no less than 50% reserve deflection beyond actual operating conditions.
- H. Attachment plates to be cast into housekeeping pads, concrete inserts, beam clamps, etc. shall be provided by this Section.
- I. Coordinate the size, location and special requirements of vibration isolation equipment and systems with other Trades. Coordinate plan dimensions with size of housekeeping pads.

## 2.02 VIBRATION ISOLATOR TYPES

- A. Type A (Floor Spring and Neoprene)
  - 1. The Type A spring isolator shall:
    - a. Have a minimum outside diameter to overall height of 0.8:1.
    - b. Have corrosion resistance where exposed to corrosive environment with:
      - 1) Springs cadmium plated or electro-galvanized.
      - 2) Hardware cadmium plated.
      - 3) All other metal parts hot dip galvanized.
    - c. Have reserve deflection (from loaded to solid height) of 50% of rated deflection.
    - d. Have minimum 1/4" thick neoprene acoustical base pad on underside, unless designed otherwise.
    - e. Be designed and installed so that ends of springs remain parallel.
  - 2. Type A isolator shall be similar to Mason Industries Type SLF.
- B. Type B (Floor Spring and Neoprene Travel Limited)
  - 1. The Type B spring isolator shall be the same as Type A with the following additional features.
    - a. Built-in vertical limit stops with minimum 1/4" clearance under normal operation.
    - b. Tapped holes in top plate for bolting to equipment.
    - c. Capable of supporting equipment at fixed elevation during equipment installation. Installed and operating heights shall be identical.
    - d. Adjustable and removable spring pack with separate neoprene isolation pad.
  - 2. Type B isolator shall be similar to Mason Industries Type SLR.

- C. Type C (Spring Hanger Rod Isolator)
  - 1. Spring isolator (Type A) seated on a steel washer within a neoprene cup incorporating a rod isolation bushing.
  - 2. Spring diameters and hanger box shall allow 30° of hanger rod movement.
  - 3. When used on ductwork, provide eyebolts for attachment to duct straps.
  - 4. Type C isolator shall be similar to Mason Industries Type 30 or W30.
- D. Type D
  - 1. Double deflection neoprene isolator (minimum 0.3") encased in ductile iron or steel casing.
  - 2. Type D isolator shall be similar to Mason Industries Type Br, RBA or RCA.
- E. Type E (Elastomer Hanger Rod Isolator)
  - 1. Molded (minimum 1 3/4" thick) neoprene element with projecting bushing lining the rod clearance hole. Static deflection at rated load shall be minimum 0.035".
  - 2. Steel retainer box encasing neoprene mounting capable of supporting equipment up to (4) times the rated capacity of the element.
  - 3. Type E isolator shall be similar to Mason Industries Type HD.
- F. Type F (Combination Spring/Elastomer Hanger Rod Isolator)
  - 1. Spring and neoprene elements in a steel retainer box with the features as described for Type C and Type E isolators.
  - 2. Type F isolator shall be similar to Mason Industries Type 30N.
- G. Type G (Pad Type Elastomer Isolator)
  - 1. 0.75" minimum thickness, 50 psi maximum loading, ribbed or waffled design.
  - 2. Minimum 0.1" deflection.
  - 3. 1/16" galvanized steel plate between multiple pad layers.
  - 4. Provide load distribution plate where attachment to equipment bearing surface is less than 75% of the pad area.
  - 5. Type G isolators shall be similar to Mason Industries Type Super W.
- H. Type H (Pad Type Elastomer Isolator)
  - 1. Laminated canvas duck and neoprene, maximum loading 1000 psi, minimum 1/2" thick.
  - 2. Provide load distribution plate where attachment to equipment bearing surface is less than 75% of the pad area.
  - 3. Type H isolator shall be similar to Mason Industries Type HL.
- I. Type I (Thrust Restraints)
  - 1. A spring element similar to Type A isolator shall be combined with steel angles, back-up plates, threaded rod, washers and nuts to produce a pair of devices capable of limiting movement of air handling equipment to 1/4".
  - 2. Restraint shall be easily converted in the field from a compression type to tension type.
  - 3. Unit shall be factory precompressed.
  - 4. Thrust restraints shall be installed on all cabinet fan heads, axial or centrifugal fans whose thrust exceeds 10% of unit weight.
  - 5. Type I restraint shall be similar to Mason Industries Type WB.
- J. Type J (Steel Rails)
  - 1. Steel members of sufficient strength to prevent equipment flexure during operation.
  - 2. Height saving brackets as required to reduce operating height.
  - 3. Type J isolator shall be similar to Mason Industries Type ICS.

- K. Type K (Pipe Anchors and Guides)
  - 1. Acoustical pipe anchor or guide, consisting of a telescopic arrangement of (2) sizes of steel tubing separated by a minimum 1/2" thickness of Type H pad.
  - 2. Vertical restraints shall be provided by a similar material arranged to prevent vertical travel in either direction (anchors only).
  - 3. Allowable loads on isolation materials shall not exceed 500 psi, and the design shall be balanced for equal resistance in any direction.
  - 4. Type K anchor shall be similar to Mason Industries Type ADA.
  
- L. Type L (Isolated Clevis Hanger)
  - 1. Combination clevis or rod roller hanger and a Type C, E, or F, isolation hanger.
  - 2. System shall be precompressed to allow for rod insertion and standard leveling.
  - 3. Type L hanger shall include Mason Industries Type CCB clevis brace.

## 2.03 EQUIPMENT BASES

- A. All curbs and roof rails are to be bolted or welded to the building steel or concrete deck and shall be wind restrained for 110 mph wind loads.
  
- B. Type B-1 (Integral Structural Steel Base)
  - 1. The integral structural steel base shall be reinforced as required to prevent base flexure at equipment start-up and misalignment of driver and driven units. Centrifugal fan bases shall be complete with motor slide rails and shall be drilled for driver and driven units.
  - 2. Height saving brackets shall be provided, as required, to reduce operating height and maintain 1" operating clearance under base.
  - 3. Member depth shall be a minimum of 1/10 of the longest unsupported span.
  - 4. Type B-1 equipment base shall be similar to Mason Industries Type M or WF.
  
- C. Type B-2 (Concrete Inertia Base)
  - 1. Concrete inertia base shall have rectangular structural concrete forms for floating foundations. Base for split-case pumps shall be large enough to support elbows. The base depth shall be a minimum of 1/12 the longest span, but not less than 6" or greater than 14". Forms shall include concrete reinforcement consisting of 1/2" bars or angles welded in place on 6" centers both ways in a layer 1 1/2" above the bottom. Provide an additional top layer of reinforcing for all bases exceeding 10'-0" in one direction.
  - 2. Isolators shall be set into pocket housings which are an integral part of the base construction and set at the proper height to maintain 1" clearance below the base. Base shall be furnished with templates for equipment attachment and anchor bolt sleeves.
  - 3. Type B-2 equipment base shall be similar to Mason Industries Type K or KIPWF.
  
- D. Type B-3 (Spring Roof Curb)
  - 1. Curb mounted rooftop equipment shall be mounted on structural spring isolation curbs that bear directly on the roof support structure, and are flashed and waterproofed into the roof's membrane waterproofing system. Equipment manufacturer's curb shall not be used.
  - 2. All spring locations shall have removable waterproof covers to allow for spring adjustment and/or removal. Springs shall be Type A.
  - 3. Curbs shall be thermal and sound attenuating type utilizing standard 2" roof insulation supplied and installed by the Roofing Contractor.
  - 4. Unit shall be provided with wood nailer and flashing.
  - 5. Curbs shall meet all NRCA Standards.
  - 6. Curbs shall include a means of incorporating a sound barrier package, Type SBC-3 consisting of (2) layers of waterproof sheetrock furnished and installed by others.

7. Curbs installed on pitched roofs shall be factory built to compensate for elevation changes.
8. Curbs shall be similar to Mason Industries Type RSC having a minimum 3" rated static deflection.

E. Type B-4 (Flashable Roof Rail System)

1. Rooftop fans, condensing units, air handlers, etc. shall be mounted on continuous support piers that combines equipment support and isolation into (1) assembly.
2. Rails shall incorporate Type A isolators which are adjustable, removable and interchangeable after equipment has been installed.
3. The system shall maintain the same installed and operating height with or without the equipment load.
4. The system shall have full plywood nailers on all (4) sides, designed to accept membrane waterproofing and shall be dry galvanized or plastic coated.
5. Unit to be supplied with flashing.
6. Roof rail shall be similar to Mason Industries Type R-7000 having a minimum 3" rated static deflection.

F. Type B-5 (Roof Rail Base)

1. Rails shall be constructed from structural steel angles sized as required to prevent flexure and misalignment under load.
2. Each rail shall be the full length of the supported equipment and be welded to a series of Type B isolators. Bolt-on angle cross ties at the ends and center shall form (1) rigid platform.
3. Roof rail shall be similar to Mason Industries Type TRSLR.

G. Type B-6 (Non-Isolated Roof Curb)

1. Non-isolated, curb mounted rooftop equipment shall be mounted on structural curbs that meet the acceleration criteria hereinbefore defined.
2. Curbs shall accept standard 2" roof insulation furnished and installed by the Roofing Contractor.
3. Non-isolated curbs shall be similar to Mason Industries Type RRC.

## 2.04 FLEXIBLE PIPE CONNECTOR

A. All flexible connectors shall be:

1. Installed on the equipment side of the shutoff valves, horizontal and parallel to equipment shafts whenever possible. All piping between the flexible connector and the equipment shall be independently supported off the equipment base.
2. Provided wherever rigidity supported piping is connected to equipment.

B. Type FC-1 (Elastomer Connector)

1. Manufactured of nylon tire cord and EPDM, both molded and cured in hydraulic presses. Neoprene used in lieu of EPDM is not acceptable.
2. Straight connectors to have (2) spheres reinforced with a molded in external ductile iron ring between the spheres.
3. Rated at 250 psig/170°F, dropping in a straight line to 170 psig/250°F for sizes 1 1/2" to 12".
4. All sizes shall employ control cables with neoprene end fittings isolated from anchor plates by means of 1/2" bridge bearing neoprene bushings.
5. Connectors shall be installed pre-extended per manufacturer's recommendations to prevent elongation under pressure.
6. Minimum safety factory of 3.6:1 at maximum pressure ratings shall be certified by test reports. Submittals shall also include (2) test reports by independent consultants showing

minimum reduction of 20 dB in vibration accelerations and 10 dB in sound pressure levels at typical blade passage frequencies.

7. Connectors bolted to Victaulic type coupling or gage, butterfly or check valves to have a minimum 5/8" flange spacer installed between the connector and the coupling flange.
8. Connectors for pipe size 2" and smaller shall have threaded female union couplings on each end. Larger pipe sizes shall be fitted with flange couplings.
9. Type FC-1 flexible connector shall be similar to Mason Industries Super-Flex Type MFTNC or MFTFU.

C. Type FC-2 (Flexible Stainless Steel Hose)

1. Stainless steel hose and braid rated with 3:1 safety factor.
2. 2" and smaller with male nipples, 2 1/2" and larger with fixed steel flanges.
3. Lengths as follows:

| Size  |   | Length | Size  |   | Length | Size |   | Length |
|-------|---|--------|-------|---|--------|------|---|--------|
| 1/2   | x | 9      | 2     | x | 14     | 8    | x | 22     |
| 3/4   | x | 10     | 2 1/2 | x | 13     | 10   | x | 26     |
| 1     | x | 11     | 3     | x | 14     | 12   | x | 28     |
| 1 1/4 | x | 12     | 4     | x | 15     | 14   | x | 30     |
| 1 1/2 | x | 13     | 5     | x | 19     | 16   | x | 32     |
|       |   |        | 6     | x | 20     |      |   |        |

4. Type FC-2 flexible connector shall be similar to Mason Industries Type BSS.

D. Type FC-3 (Unbraided Exhaust Hose)

1. Low pressure stainless steel annularly corrugated with flanged ends.
2. Maximum temperature of 1500°F.
3. Lengths (in inches) as follows:

| Size  |   | Length | Size |   | Length |
|-------|---|--------|------|---|--------|
| 2 1/2 | x | 15     | 8    | x | 22     |
| 3     | x | 16     | 10   | x | 26     |
| 4     | x | 17     | 12   | x | 28     |
| 5     | x | 18     | 14   | x | 30     |
| 6     | x | 19     | 16   | x | 32     |

4. Type FC-3 flexible connector shall be Mason Industries Type SDL-RF or equal by approved manufacturer.

E. Type FC-4 (Bronze Braided Flexible Hose)

1. Bronze hose and braid rated with a minimum 3:1 safety factor (minimum 150 psi).
2. Copper tube ends.
3. Minimum lengths (in inches) as follows:

| Size |   | Length | Size  |   | Length | Size  |   | Length |
|------|---|--------|-------|---|--------|-------|---|--------|
| 1/8  | x | 7 1/2  | 3/4   | x | 11 1/2 | 3     | x | 27     |
| 1/4  | x | 8 1/4  | 1     | x | 13     | 3 1/2 | x | 32     |
| 3/8  | x | 9      | 1 1/4 | x | 14 3/4 | 4     | x | 33     |
| 1/2  | x | 9 3/4  | 1 1/2 | x | 17     | 5     | x | 41     |
| 5/8  | x | 10     | 2     | x | 20     | 6     | x | 48     |
|      |   |        | 2 1/2 | x | 24     |       |   |        |

4. Type FC-4 flexible connector shall be similar to Mason Industries Type BFF.

2.05 VIBRATION ISOLATION SCHEDULE

| Equipment                             | HP   | Mtng    | On Grade **** |            |            | Above Grade |              |            |
|---------------------------------------|------|---------|---------------|------------|------------|-------------|--------------|------------|
|                                       |      |         | Isol          | Defl       | Base       | Isol        | Defl         | Base       |
| Axial Fans                            |      | Flr Clg | A&I           | .75        | B-1        | A**<br>F&I  | See<br>Guide | B-2        |
| Cabinet Type Fans & Packaged AHUs     | To 1 | Flr Clg | D<br>---      | .50<br>--- | ---        | D           | See<br>Guide | ---        |
| Cabinet Type Fans & Packaged AHUs     | >1   | Flr Clg | A<br>---      | 1.0<br>--- | ---        | A **<br>F   | See<br>Guide | ---        |
| Centrifugal Fans                      |      | Flr Clg | A<br>---      | 1.0<br>--- | B-1<br>*** | A**<br>F    | See<br>Guide | B-2<br>*** |
| Plenum Fan                            |      | Flr Clg | A<br>---      | 1.0<br>--- | B-1<br>*** | A**<br>F    | See<br>Guide | B-2<br>*** |
| Centrifugal Fans Arrangement 9 and 10 |      | Flr Clg | A<br>---      | 1.0<br>--- | B-1<br>--- | A**<br>F    | See<br>Guide | B-2        |

- \* Used on vertically arranged units. Rails shall be 1.5 times the unit height.
- \*\* Substitute Type B isolator for Outdoor installations.
- \*\*\* Substitute Type B-2 base for floor mounted Class 2 and 3 fans.
- \*\*\*\* "On Grade" shall mean slab on grade only.
- \*\*\*\*\* Fans in all units shall be isolated in accordance with chart.

Notes:

1. "Isol", "Base" and "Restr" columns indicate letter type as appears in the specs.
2. "Mtng" refers to method of support of equipment from the structure.
3. "See Guide" indicates isolator deflection selection to be taken from Deflection Guide below.

| Deflection Guide |               |
|------------------|---------------|
| RPM              | MW Deflection |
| <400             | 3.5"          |
| <600             | 2.5"          |
| >600             | 1.5"          |

**PART 3 – EXECUTION**

3.01 GENERAL

- A. Isolation systems must be installed in strict accordance with the manufacturer's written instructions and submittal data. Vibration isolators shall not cause any change of position of equipment resulting in stress on equipment connections.
- B. Design Criteria
  1. All mechanical equipment such as pumps, fans, air handling units, etc. shall be isolated from the building structure by means of noise and vibration isolators.
  2. All piping ductwork in mechanical equipment rooms and penthouses shall be isolated from the building structure by means of noise and vibration isolation hangers.



3. Piping and/or ductwork penetrations through floors and walls shall not be rigidly connected to the building structure. Provide sleeves with clearances around the outside, as recommended by the vibration materials manufacturer. All such penetrations shall be smokeproofed and firestopped in an approved manner as hereinbefore specified.
4. Generally, isolation facilities shall be designed to limit equipment room floor or roof loading to a maximum of 50 lbs./sq.ft. and vibration isolators shall be carefully and specifically selected for each piece of equipment.
5. Flexible duct connections at fans and air handling units shall have a minimum clear gap of 3" between metal collars. Flexible connectors exposed to the weather shall be weatherproofed by the Mechanical Contractor. Refer to the Sheet Metal Section of this specification for requirements of flexible duct connections.
6. Piping found to have water hammer or other objectionable vibration or noise which cannot be eliminated by proper grading or other natural means shall be braced, trapped, hung with vibration isolation hangers, equipped with air chambers or mechanical shock absorbers, flexible pipe connectors, or otherwise silenced using means as approved by the Architect.
7. Motor driven equipment which is to be isolated shall have motor mounted on the isolated equipment or shall have motor, equipment and drive mounted on a common base.
8. The Contractor shall not install any equipment, piping or conduit which makes rigid contact with the "building" unless permitted in this Specification. Building includes, but is not limited to, slabs, beams, columns, studs and walls.
9. Isolation mounting deflection shall be (minimum) as specified or scheduled on drawings.
10. Coordinate work with other trades to avoid rigid contact with the building. Inform other trades following work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation.
11. Bring to the Architect's attention, prior to installation, any conflicts with other trades that will result in unavoidable rigid contact with equipment or piping as described herein, due to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.
12. Bring to the Architect's attention any discrepancies between the specifications and field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the contractor's expense.
13. Obtain inspection and approval of any installation to be covered or enclosed, prior to such closure.
14. Correct, at no additional cost, all installations which are deemed defective in workmanship or materials.

### 3.02 EQUIPMENT ISOLATION INSTALLATION

- A. Equipment shall be isolated and restrained as per the vibration isolation schedule at the end of this Section.
- B. Place floor mounted equipment on 4" high concrete housekeeping pads (unless detailed otherwise) properly doweled or expansion shielded to the deck to meet acceleration criteria. Anchor isolators and/or bases to housekeeping pads. Housekeeping pad concrete work shall be by Division 3. Housekeeping pads shall be sized to have a minimum of 6" of clearance all around the equipment or 12 bolt diameters, whichever is greater.
- C. Additional Requirements
  1. The minimum operating clearance under inertia bases shall be 2".
  2. The minimum operating clearance under other bases shall be 1".
  3. All bases shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the equipment, isolators and restraints.

4. The isolators shall be installed without raising the equipment.
5. After the entire installation is complete, and under full operational load, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. The blocks shall be barely free and shall be removed. Remove all debris from beneath the equipment and verify that there are not short circuits of the isolation. The equipment shall be free in all directions.
6. Install equipment with flexibility in wiring.

### 3.03 PIPING AND DUCTWORK ISOLATION INSTALLATION

- A. Isolate piping and ductwork outside shafts connected to rotating or reciprocating equipment and pressure reducing stations as follows:
  1. All water piping in mechanical rooms.
  2. Water piping within 50'-0" or 100 pipe diameters (whichever is greater) from connected isolated equipment.
- B. The isolators shall be installed with the hanger box hung as closely as possible (without direct contact) to the structure.
- C. The isolators shall be suspended from substantial structural members sized for a maximum deflection of L/360 at mid span, not from slab diaphragm, unless specifically permitted by the structural engineer.
- D. Hanger rods shall not short circuit the hanger box.
- E. Horizontal suspended water piping 1 1/4" to 2" shall be suspended by Type E isolators with a minimum 3/8" deflection. Water pipe larger than 2" shall be supported by Type F isolators with a minimum 0.75" deflection or same deflection as equipment for the first (3) locations nearest equipment, whichever is greater.
  1. Type L isolators may be substituted for the above.
  2. Horizontal floor and roof supported pipe shall be the same as above except use isolators Type D and Type A, respectively.
- F. Ductwork shall be supported by Type C isolators with a minimum 0.75" deflection.
- G. Vertical riser pipe supports, where required, under 2" diameter shall utilize Type H isolation.
- H. Vertical riser guides, where required, shall avoid direct contact of piping with the building.
- I. Pipe anchors or guides, where required, shall utilize Type K isolators.
- J. Riser sway supports, where required, shall utilize (2) neoprene elements (Type G or H) to accommodate tension and compression forces.

### 3.04 INSTALLATION INSTRUCTIONS

- A. Adjust all base and piping isolators as required to prevent stress transfer to equipment.
- B. Set steel bases for 1" clearance between housekeeping pad and base. Set concrete inertia bases for 2" clearance. Adjust equipment level.
- C. Position equipment, structural base and concrete base on blocks or wedges at proper operating height.

- D. Provide all equipment and provide operating load conditions before transferring base isolation loads to springs and removing wedges.
- E. Install inertia bases of type and thickness, with isolators of type and static deflection indicated.
- F. Provide isolators as specified and install in accordance with the manufacturers recommendations.
- G. Provide forms for 4" high housekeeping pads under all floor mounted equipment, including those with inertia blocks. Provide necessary reinforcing.
- H. Install equipment with flexibility in wiring connection.
- I. Verify all installed isolators and mounting system permit equipment motion in all directions.
- J. Adjust or provide additional resilient restraints to flexibly limit lateral motion to 1/4" during start-up of equipment.
- K. Before start-up, clean out all foreign matter between bases and equipment to prevent short circuit.
- L. Install flexible pipe connectors on pipe connected to equipment supported by vibration isolation. Hook up piping to equipment and mains with spool pieces. After completion of pressure testing but prior to start-up, remove spool pieces and install flexible pipe connectors. Identify spool pieces as to equipment served and either entering or leaving.

**END OF SECTION 23 05 98**

## SECTION 230713 – DUCT INSULATION

### PART 1 – GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Section, apply to this Section.

#### 1.02 WORK INCLUDED

- A. Furnish and install all duct insulation, vapor barriers, jackets, finishes, adhesives, cements and accessories to make a complete and insulated system of all ductwork, fittings, joints, offsets and accessories specified herein.
- B. All insulation system materials shall conform to the maximum flame spread/smoke developed ratings specified herein.

#### 1.03 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

#### 1.04 REFERENCES

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.
- B. Material standards shall be as specified or detailed hereinafter and as follows:
  1. ASTM B 209 – Standard Specification for Aluminum and Aluminum-Alloy Steel and Plate.
  2. ASTM B 209M – Standard Specification for Aluminum and Aluminum-Alloy Sheet and plate (Metric).
  3. ASTM C 518 – Standard Test method for Steady-State Heat Flux Measurements and Thermal Insulating and Finishing Cement.
  4. ASTM C 553 – Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
  5. ASTM C 612 – Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
  6. ASTM C 921 – Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
  7. ASTM C 1071 – Standard Specification for Thermal and Acoustical Insulation (Glass, Fiber, Duct Lining Material).
  8. ASTM E 84 – Standard Test Method for Surface Burning Characteristics of Building Materials.
  9. ASTM E 96 – Standard Test Methods for Water Vapor Transmission of Materials.
  10. ASTM E 162 – Standard Test Method for Surface flammability of Materials Using a Radiant Heat Energy Source.
  11. ASTM G 21 – Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
  12. NFPA 96 – Ventilation Control and Fire Protection of Commercial Cooking Operations.

13. NFPA 255 – Standard Method of Test of Surface Burning Characteristics of Building Materials.
14. SMACNA (DCS) – HVAC Duct Construction Standards – Metal and Flexible.
15. UL 723 – Standard for Test for Surface Burning Characteristics of Building Materials.
16. ANSI/ASHRAE 90.1 - Energy Conservation in New Building Design.

#### 1.05 SUBMITTALS

- A. See Section 230500 and General Conditions for additional requirements.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

#### 1.06 QUALITY ASSURANCE

- A. All insulation materials, finishes, coatings, cements, tapes, jackets and other insulation accessories shall have minimum composite or individual fire hazard ratings as well as thickness and "C" values conforming to State Building Codes which control building construction materials that may be used on this project. Where specification requirements exceed the Code requirements, the specification shall govern.
- B. Insulation for the various duct systems and associated equipment shall be composed of materials which are non-combustible and/or provide a fire resistive system of insulation which complies with the applicable Code having jurisdiction. Generally, it is required that fire hazard ratings shall not exceed the following, except as noted:
  1. Flame Spread Rating: 25 (No Exceptions)
  2. Smoke Developed Rating: 50
- C. All fire hazard ratings shall be as determined by NFPA 255 "Method of Test of Surface Burning Characteristics of Building Materials", ASTM E84 or UL 723.
- D. All insulation materials herein specified shall be used subject to the manufacturer's temperature limitations and their compatibility with other materials.
- E. Installation of all insulation work shall be executed by a qualified Insulation Contractor who is thoroughly experienced in this particular type of work and who has adequate facilities and equipment for installation of all insulation work herein specified and who is familiar with the requirements of the Code enforcing Authorities as to fire hazard rating.
- F. The finished installation shall present a neat and workmanlike appearance with all jackets smooth, with all vapor barriers sealed and intact.
- G. Where insulation is specified for ductwork, insulate similarly all collars, dampers, edges, joints, etc. connected to system subject to heat loss or gain. Do not cover damper actuators or other maintenance points on equipment unless identified on the insulation with removable access panels or covers.

1.07 REGULATORY REQUIREMENTS

- A. Conform to maximum flame spread/smoke developed rating of 25/50 in accordance with ASTM E 84, NFPA 255, or UL 723.

1.08 DELIVERY, STORAGE AND PROTECTION

- A. Accept materials on site, labeled with manufacturer's identification, product density and thickness.
- B. All materials shall be stored in a dry area free from moisture and debris.

1.09 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during and after installation for minimum of 24 hours.

**PART 2 – PRODUCTS**

2.01 GENERAL

- A. Acceptable for property types indicated contingent upon products' compliance with the specifications.
  - 1. Insulation:
    - a. Manville Corporation.
    - b. Owens-Corning Fiberglass Corporation.
    - c. Armstrong World Industries, Incorporated.
    - d. Certainteed Corporation.
    - e. Knauf
  - 2. Mastics and adhesives:
    - a. Childers Products Company.
    - b. H. B. Fuller Company, Foster Products Division.
    - c. 3M Company Adhesives, Coatings and Sealers.
    - d. Armstrong World Industries, Incorporated.
    - e. Ruston Plant.
    - f. Chicago-Mastic
    - g. Insul-Coustic
    - h. St. Clair Rubber
    - i. Vimasco
    - j. Baldwin-Ehret-Hill
  - 3. PVC fitting covers:
    - a. Manville, Corporation.
    - b. Ceel-Co.
    - c. Certainteed, Corp.
    - d. Cell Co. Plastics
- B. Adhesives and insulation materials: Composite fire and smoke hazard ratings maximum 25 for flame spread and 50 for smoke developed for pipe insulation. Adhesives to be waterproof when cured.

- C. The installation of thermal insulating materials coverings and coatings containing asbestos fibers is forbidden.
- D. Insulation shall not be chemically reactive to the metal over which it is applied. Insulation installed on steel shall be neutral or slightly alkaline. Insulation installed on aluminum shall be neutral or slightly acidic.

## 2.02 MATERIALS AND COMPONENTS

### A. Faced Flexible Fiberglass Insulation

1. Faced flexible fiber glass duct insulation shall be equal and equivalent to Owens-Corning Fiberglas Faced Duct Wrap, Series ED 100, FRK-25 having an approximate density of 1.0 lb./cu.ft. and an approximate thermal conductivity of 0.30 at 75° F.
2. Insulation shall be tightly wrapped on the duct work with all circumferential joints butted and longitudinal joints laped 2 inches and stapled. All joints shall be sealed with approved adhesive. Adhere insulation to ducts with 4 inch wide strips of an approved bonding adhesive, at 18 inches on center. Additionally, secure insulation to bottom of rectangular ducts over 24 inches wide with weld pins or stickclips at no more than 18 inches on center.
  - a. Alternative means of securing insulation to ducts will be permitted, subject to the manufacturer's recommendations and the Architect's written approval.
3. Insulation shall be butted with facing overlapping all joints at least 2 inches and sealed with approved fire retardant vapor barrier adhesive. All breaks, punctures and pin penetration in facing, shall be sealed with vapor barrier tape per the manufacturer's published installation instructions.

### B. Rigid Fiberglass Board Insulation

1. Rigid fiberglass board insulation shall be equal to Owens-Corning Fiberglas 25 with ASJ having an approximate density of 4.2 lbs./cu.ft. and an approximate thermal conductivity of 0.25 at 75°F.
2. The insulation shall be applied by use of weld pins or stick clips. Such fasteners shall be spaced 3 inches from each corner of the board with intermediate pins spaced no more than 12 inches on center. Pin caps shall be covered with a round vapor seal patch that matches the jacket on the ASJ board.
3. Ducts, plenums and equipment having sharp bend shall have the insulation scored as required to conform to the curved surfaces to provide a neat and workmanlike appearance when finished.
4. All insulation edges and joints shall be sealed with a fire retardant vapor barrier adhesive, reinforced with a vapor barrier tape similar to that of the board facing. Tape shall be 3 to 5 inches wide as recommended by the particular manufacturer.
5. The above specified insulation will be used in all areas, and it is intended that the finish present a neat and uniform appearance as to color and workmanship.

C. Insulation Facing

1. Code ASJ: All service jacket composed of high intensity white chemically treated Kraft paper reinforced with fiberglass yarn and mesh and laminated to aluminum foil with a fire retardant adhesive. Longitudinal laps and butt strips shall be a minimum of 3 inches.
2. Code FSKL: 0.35 mil aluminum foil reinforced with fiberglass yarn reinforcing scrim and laminated to chemically treated fire resistive Kraft paper having a minimum 35 pound per inch width tensile strength when tested in accordance with ASTM D 828. Water vapor permeability 0.04 perms. Longitudinal laps and butt strips shall be a minimum of 3 inches.

D. Additional Insulation Jacket

1. ADJ-1: Approximately 6 ounce per square yard glass cloth jacket with thread count of 5 strands per square inch.
2. ADJ-2: Approximately 2 ounce per square yard glass cloth jacket with pipe. Thread count of 10 strands by 10 strands per square inch. Jacket shall be used for covering pipe and pipe fittings.
3. ADJ-3a: 0.016 inch thick aluminum jacket conforming to ASTM B-209 with a 1 mil factory applied polykraft moisture barrier. Longitudinal joints shall be placed at the side of the pipe facing downward at either the 4 o'clock or 8 o'clock position so as to shed water. Aluminum fitting covers, two piece elbows, tees, valve and flange covers, etc., with a 1 mil polykraft or acrylic vapor barrier.
4. ADJ-3b: 0.020 inch thick type aluminum jacket conforming to ASTM B-209 with a 3 mil factory applied polykraft moisture barrier. Longitudinal joints shall be placed at the side of the pipe facing downward at either the 4 o'clock or 8 o'clock position so as to shed water. Aluminum fitting covers, two piece elbows, tees, valve and flange covers, etc., with a 3 mil polykraft or acrylic vapor barrier.
5. ADJ-4: 20 mil PVC jacket suitable for all types of paint. Similar to Manville Zeston 25/50.
6. ADJ-5: shall be a Cell-Co plastic jacket with the following color coded pattern:
  - a. Steam (HP/LP): White
  - b. Condensate (Pump/Gravity): White
  - c. Hot Water: Orange
  - d. Chilled Water (Above 40°F): Blue
  - e. Vent: Black
  - f. City Water: Gray
  - g. Other: Yellow-green
7. ADJ-6 A finish jacket of an Asbestos-free and woven as high temperature, heat-resistant fabric. Lagging Cloth having a treated weight of 24 oz./sq.yd. Material shall be suitable for a sustained operation at 1100°F.
8. ADJ-7: 0.16-inch thick type T-316 stainless steel jacket. Alloys conforming to ASTM A-240. System shall have a 3-mil polykraft vapor barrier.

E. Adhesives

1. Code ADH-1: Fibrous adhesive, non-flammable, quick setting adhesive for calcium silicate. Similar to Childers CP-97, 98.
2. Code ADH-2: Fast-drying vinyl base coating and lagging adhesive. Similar to Childers CP-50A HV2.
3. Code ADH-3: Fast-drying neoprene base adhesive for lap joints of foil-faced facing applied over pipe insulation. Similar to Childers CP-82.
4. Code ADH-4: Adhesive for use in adhering fiberglass board or blanket insulation to pipe and equipment. 3M Company Insulation Adhesive No. 35 or 38 non-flammable adhesive.



- F. Caulking Components
1. Code CC-1: For use with foam glass and/or joint sealant applications. Flexible elastomeric vapor barrier sealant. Similar to Childers CP-76.
- G. Mastics
1. Code MAS-1: Vapor barrier mastic made with an elastomeric resin. For indoor use. Similar to Childers CP-30.
  2. Code MAS-2: A non-water vapor barrier asphaltic emulsion coating, breathing type, for above ground installations. Similar to Childers CP-10.
  3. Code MAS-3: Vapor barrier mastic made with an elastomeric resin. For outdoor use.
- H. Tie Wire
1. Tie wire for securing insulation in place shall be type 304 stainless steel annealed steel wire of gauge and proper spacing as recommended by the insulation manufacturer. Wire shall be drawn up tightly enough to become embedded in the insulation and the ends of the loop twisted, bent over, and pressed into the insulation so as to leave no ends protruding.
- I. Banding
1. 3/8 inch x 0.02 inch type 304 stainless steel for pipe insulation.
  2. 3/4 inch x 0.02 inch type 304 stainless steel for additional insulation jackets.
- J. Wire Mesh
1. Wire mesh shall be one inch by No. 20 BGW hexagonal mesh galvanized.
  2. Expanded metal: Expanded metal shall be 1/2 inch Hi-Rib metal lath of copper bearing steel.
- K. Tape
1. Lead foil tape, where specified, shall be 3M Company Lead Foil Tape No. 422, 4 mil thick, acrylic adhesive, 2 inch wide.
  2. Vinyl plastic tape, silver gray, flame resistant, vapor barrier sealant tape on rigid and flexible insulation material for warm or cold air ducts. Similar to 3M Company Duct Sealing Tape No. 474.
  3. Aluminum foil tape, dead soft aluminum foil, point seal on stick pin, metal patching, moisture barrier, heat reflecting and general sealing on aluminum facing foil. Similar to 3M Company Aluminum Foil Tape No. 425.
- L. Staples
1. Staples shall be galvanized clad outward clinching insulation staples.
- M. Insulating Cement
1. Insulating cement shall be a mineral-fiber (wool) ASTM C 195 base material having essentially the same insulating characteristics as the adjacent insulation. Similar to PABCO High Temperature Insulating Cement. Insulating cement shall be applied in layers to a maximum thickness of 1/2 inch. Each layer shall be allowed to dry thoroughly before subsequent layers are applied.
- N. Finishing Cement
1. Finishing cement ASTM C 449 shall be diatomaceous silica thermal insulating materials with a suitable proportion of heat resistant binder, hydraulic setting insulating cement capable of withstanding maximum temperature of 700 degrees Fahrenheit. When mixed with water it shall be a plastic mix suitable for trowel applications and shall present a hard, smooth and durable surface after drying. Similar to PABCO No. 127.

2. Combination insulating and finishing cement:
  - a. Similar to Ryder One Coat or equal.
3. Welding studs:
  - a. Welding studs shall be capacitor type split pin or TCP tipped insulation pins with speed clips. Similar to Nelson Stud Welding Spec. 28.
4. Corner angles on insulation of ducts, plenums and equipment in finished areas shall be formed of 28 gauge, 1 inch by 1 inch aluminum adhered to heavy Kraft paper having 2 inch by 2 inch by 2 inch wings to protect external corners under glass cloth jackets.
  - a. Corner beads shall be 26 gauge galvanized steel with 2 ½ inch wings (exposed ducts on roof).

### **PART 3 – EXECUTION**

#### **3.01 INSTALLATION OF INSULATION**

- A. All insulation shall be applied by experienced insulating contractors in accordance with best Trade practice.
- B. Test, inspect and clean all surfaces of ductwork to be insulated before applying insulation.
- C. Take all possible precautions to protect work of other Trades. Provide protective covering as required to accomplish this end. This Trade shall be responsible for returning all equipment and material to its original new condition and appearance where damage occurs due to his neglect.
- D. All ductwork shall have been tested and approved prior to installation of insulation.
- E. All ductwork and plenum or surfaces, where subject to condensation on the outside, shall be insulated including vapor seal finish.
- F. All surfaces to be insulated shall be clean, dry and free from dirt and scale when insulation is being applied. Insulation shall be dry at the time of installation and before and during the process of finished application.
- G. Butt ends will not be allowed. However, where required and approved by Architect, jacket material shall be pasted over exposed ends and banded to give a neat and finished appearance. Exposed fiberglass material will not be permitted.
- H. Surfaces of insulation shall be smooth, even and true to line with jackets drawn tight and smoothly secured. Scrap pieces of insulation shall not be used where a full length section will fit.
- I. The methods of application of insulation, finishes, adhesives, cements, accessories are generally specified under the material headings of these specifications. Where not specifically detailed, it is intended that they are equal or exceed the manufacturer's published recommendations, existing at time of bid openings, subject to the approval of the Architect.
- J. Butt covering neatly to walls, floors, ceiling. Apply band at end and position so band covers gap between surface and insulation where exposed.
- K. Fastenings: Provide where required to securely hold insulation. Apply adhesive and weld pins and/or stick clips on exposed risers to prevent slipping and turning of insulation. .

- L. Thickness of insulation shall not be compromised due to piping interferences, improper installation or any other reason.

**PART 4 – SCHEDULES**

**4.01 DUCTWORK INSULATION SCHEDULE:**

| Service   | Type Insulation and Thickness (Inches)     | Facing | Additional Jacket |
|---|--|--------|-------------------|
| Outside Air Intake and Relief Air Ducts and Plenums, Supply Air Ductwork (Exposed or in Mechanical Room within 8'-0" of finished floor) | Rigid Fiberglass Board Insulation 2"       | FSKL   |                   |
| Supply Air Ductwork (Concealed or in Mechanical Room above 8'-0" from finished floor)   | Flexible Fiberglass w/Vapor Barrier 1 1/2" | FSKL   |                   |
| Others not scheduled with system temperatures below 60°F or above 90°F  | Flexible Fiberglass w/Vapor Barrier 1"     | FSKL   |                   |

- A. HVAC Insulation Schedule Notes
  - 1. Provide vapor barrier on all ductwork insulation.

**END OF SECTION 23 07 13**

## SECTION 230719 – HVAC PIPING INSULATION

### PART 1 – GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

#### 1.02 WORK INCLUDED

- A. Furnish and install all piping insulation, vapor barriers, jackets, finishes, adhesives, cements and accessories to make a complete insulated system for all piping, valves, fittings, joints, offsets and flanges specified herein.
- B. All insulation system materials shall conform to the maximum flame spread/smoke developed ratings specified herein.
- C. Hard insulation material shall be provided at all hangers.
- D. Insulate the following:
  - 1. Piping, valves, fittings, elbows, flanges and accessories.

#### 1.03 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Section of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

#### 1.04 REFERENCES

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.
- B. Material standards shall be as specified or detailed hereinafter and as follows:
  - 1. ASTM A 666 – Standard Specification for Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar.
  - 2. ASTM B 209 – Standard Specification for Aluminum and Aluminum-Alloy Steel and Plate.
  - 3. ASTM B 209M – Standard Specification for Aluminum and Aluminum-Alloy Sheet and plate (Metric).
  - 4. ASTM C 177 – Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus.
  - 5. ASTM C 195 – Standard Specification for Mineral Fiber Thermal Insulating Cement.
  - 6. ASTM C 240 – Standard Test Methods of Testing Cellular Glass Insulation Block.
  - 7. ASTM C 449/C 449M – Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
  - 8. ASTM C 518 – Standard Test method for Steady-State Heat Flux Measurements and Thermal Insulating and Finishing Cement.
  - 9. ASTM C 533 – Standard Specification for Calcium Silicate Block and Pipe Terminal Insulation.
  - 10. ASTM C 534 – Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

11. ASTM C 547 – Standard Specification for Mineral Fiber Pipe Insulation.
12. ASTM C 552 – Standard Specification for Cellular Glass Thermal Insulation.
13. ASTM C 578 – Standard Specification for Preformed, Cellular Polystyrene Thermal Insulation.
14. ASTM C 591 – Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
15. ASTM C 610 – Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation.
16. ASTM C 795 – Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
17. ASTM C 921 – Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
18. ASTM D 1056 – Standard Specification for Flexible Cellular Materials – Sponge or Expanded Rubber.
19. ASTM D 1667 – Standard Specification for Flexible Cellular Materials – vinyl Chloride Polymers and Copolymers (Closed-Cell Foam).
20. ASTM D 1784 – Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
21. ASTM D 2842 – Standard Test Method for Water Absorption of Rigid Cellular Plastics.
22. ASTM E 84 – Standard Test Method for Surface Burning Characteristics of Building Materials.
23. ASTM E 96 – Standard Test Methods for Water Vapor Transmission Materials.
24. NFPA 225 – Standard Method of Test of Surface Burning Characteristics of Building Materials.
25. UL 723 – Standard for Test for Surface Burning Characteristics of Building Materials.
26. ANSI/ASHRAE 90.1 – Energy Conservation in New Buildings.

#### 1.05 SUBMITTALS

- A. See Section 230500 and General Conditions for additional requirements.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.
- D. Installation Graphic Details.

#### 1.06 QUALITY ASSURANCE

- A. All insulation materials, finishes, coatings, cements, jackets and other insulation accessories shall have minimum composite or individual fire hazard ratings as well as thickness and "C" values conforming to State Building Codes which control building construction materials that may be used on this project. Where specification requirements exceed the Code requirements, the specification shall govern.
- B. Piping insulation for the various piping systems and associated equipment shall be composed of materials which are non-combustible and/or provide a fire resistive system of insulation which complies with the applicable Code having jurisdiction. Generally, it is required that fire hazard ratings shall not exceed the following, except as noted:
  1. Flame Spread Rating 25 (No Exceptions)
  2. Smoke Developed Rating: 50

- C. All fire hazard ratings shall be as determined by NFPA 255 "Method of Test of Surface Burning Characteristics of Building Materials", ASTM E84 or UL 723.
- D. All insulation materials herein specified shall be used subject to the manufacturer's temperature limitations and their compatibility with other materials.
- E. Installation of all insulation work shall be executed by a qualified Insulation Contractor who is thoroughly experienced in this particular type of work and who has adequate facilities and equipment for installation of all insulation work herein specified and who is familiar with the requirements of the Code enforcing Authorities as to fire hazard rating.
- F. The finished installation shall present a neat and workmanlike appearance with all jackets smooth, with all vapor barriers sealed and intact.
- G. Where insulation is specified for piping, insulate similarly all connections, vents, drains and any piping connected to system subject to heat loss or gain. Do not cover vent petcocks, cleanouts or other maintenance points on equipment unless identified on the insulation with removable access panels or covers.
- H. All chilled water system piping, components and accessories are to be insulated in a manner so as to provide a complete, uninterrupted vapor barrier.

#### 1.07 REGULATORY REQUIREMENTS

- A. Conform to maximum flame spread/smoke developed rating of 25/50 in accordance with ASTM E 84, NFPA 255, or UL 723.

#### 1.08 DELIVERY, STORAGE AND PROTECTION

- A. Accept materials on site, labeled with manufacturer's identification, product density and thickness.
- B. All materials shall be stored in a dry area free from moisture and debris.

#### 1.09 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during and after installation for minimum of 24 hours.

### **PART 2 – PRODUCTS**

#### 2.01 GENERAL

- A. Manufacturers acceptable for product types indicated contingent upon products' compliance with the specifications.
  - 1. Insulation:
    - a. Manville Corporation.
    - b. Owens-Corning Fiberglass Corporation.
    - c. Armstrong World Industries, Incorporated.
    - d. Certainteed Corporation.
    - e. Knauf

- f. Koolphen K (chilled water only)
- g. Trymer (chilled water only)
- 2. Mastics and adhesives:
  - a. Childers Products Company.
  - b. H. B. Fuller Company, Foster Products Division.
  - c. 3M Company Adhesives, Coatings and Sealers.
  - d. Armstrong World Industries, Incorporated.
  - e. Ruston Plant.
  - f. Chicago-Mastic
  - g. Insul-Coustic
  - h. St. Clair Rubber
  - i. Vimasco
  - j. Baldwin-Ehret-Hill
- 3. Pipe insulation of hanger and support:
  - a. Pipe Shields, Inc.
  - b. Rilco Manufacturing Company.
  - c. Elcen Metal Products Company.
  - d. Power Piping Company.
  - e. NPS Industries.
- 4. PVC fitting covers:
  - a. Manville, Corporation.
  - b. Ceel-Co.
  - c. Certainteed, Corp.
  - d. Cell Co. Plastics

- B. Adhesives and insulation materials: Composite fire and smoke hazard ratings maximum 25 for flame spread and 50 for smoke developed for pipe insulation. Adhesives to be waterproof when cured.
- C. The installation of thermal insulating materials coverings and coatings containing asbestos fibers is forbidden.
- D. Insulation shall not be chemically reactive to the metal over which it is applied. Insulation installed on steel shall be neutral or slightly alkaline. Insulation installed on aluminum shall be neutral or slightly acidic.

## 2.02 MATERIALS AND COMPONENTS

- A. Fiberglass insulation:
  - 1. Premolded pipe fiberglass: Recommended temperature to 850 degrees Fahrenheit with facing. Molded in one piece split or hinged circular sections in three foot lengths for piping and tubing. Insulation shall be made from long, fine, glass fibers bonded together with a thermosetting resin. Insulation shall have a minimum density of 4.0 pounds per cubic foot and a K value of 0.23 at 75 degrees Fahrenheit mean temperature. Insulation furnished with facing as specified below and as indicated in insulation schedule. Insulation similar to Owens-Corning Type SSL-II. Pressure sensitive tapes using rubber based or acrylic based adhesives are not permitted.
  - 2. Pipe and tank fiberglass: Recommended temperature to 450 degrees F with facing. Insulation shall be made from long, fine, glass fibers bonded together with a thermosetting resin. Insulation shall have a minimum density of 3 pounds per cubic foot and a k-value of 0.27 btu in/(Hr sq.ft. degree F) at 75 degrees F main temperature. Insulation furnished with facing as specified below and as indicated in insulation schedule. Insulation similar to Manville pipe and tank insulation. Pressure sensitive tapes using rubber based or acrylic based adhesives are not permitted.

3. Flexible fiberglass: Recommended temperature to 250 degrees Fahrenheit. Glass fibrous flexible blanket insulation having density of 0.75 pounds per cubic foot and a K value of 0.30 at 75 degrees mean temperature. Insulation furnished with facing as specified below and indicated in insulation schedule. Insulation and jacket similar to Owens-Corning Type SSL-II.
  4. Use pipe and tank fiberglass only when premolded pipe fiberglass is not available. Pipe and tank insulation shall not be used on pipe sizes 24 inches and smaller.
- B. Hydrous Calcium Silicate Pipe Insulation
1. Molded, rigid, asbestos free, hydrous calcium silicate water resistant pipe insulation shall be Owens-Corning Fiberglas Kaylo 10 or Manville Thermo-12, molded to dimensional standards conforming to the pipe. Insulation shall have an approximate density of 11 lbs./cu.ft., an approximate thermal conductivity of 0.41 at 200°F mean temperature and shall be suitable for application on surfaces which reach 1200°F. Additional jacket, as hereinafter specified, shall be applied in the field. This material shall be used in finished and concealed areas. In all areas, insulation shall have all joints made with an approved insulation cement to prevent heat leakage through joints. Insulation shall be secured by wire on 9 inch centers.
  2. Valves, flanges and fittings occurring in lines insulated with calcium silicate insulation shall be covered with fabricated, mitered segments of molded calcium silicate of thickness equal to insulation on adjacent pipe, wired in place and made smooth with a thin coat of insulating cement.
    - a. Fittings on pipes 2 inches and smaller may be insulated with insulating cement to a thickness equal to that of adjacent pipe insulation. All fittings shall be finished with glass fabric embedded in fire retardant adhesive
- C. Chilled Water Pipe Insulation
1. Phenolic foam insulation shall be Koolphen K or equal. Insulation shall have a density of 2.2 lbs./cu.ft., a thermal conductivity of 0.13 at 75°F, and shall be suitable for installation on surfaces which read 200°F.
- D. Insulation facing:
1. Code ASJ: All service jacket composed of high intensity white chemically treated Kraft paper reinforced with fiberglass yarn and mesh and laminated to aluminum foil with a fire retardant adhesive. Longitudinal laps and butt strips shall be a minimum of 3 inches.
  2. Code FSKL: 0.35 mil aluminum foil reinforced with fiberglass yarn reinforcing scrim and laminated to chemically treated fire resistive Kraft paper having a minimum 35 pound per inch width tensile strength when tested in accordance with ASTM D 828. Water vapor permeability 0.04 perms. Longitudinal laps and butt strips shall be a minimum of 3 inches.
- E. Additional insulation jacket:
1. ADJ-1: Approximately 6 ounce per square yard glass cloth jacket with thread count of 5 strands per square inch.
  2. ADJ-2: Approximately 2 ounce per square yard glass cloth jacket with a thread count of 10 strands by 10 strands per square inch. Jacket shall be used for covering pipe and pipe fittings.
  3. ADJ-3a: 0.016 inch thick aluminum jacket conforming to ASTM B-209 with a 1 mil factory applied polykraft moisture barrier. Longitudinal joints shall be placed at the side of the pipe facing downward at either the 4 o'clock or 8 o'clock position so as to shed water. Aluminum fitting covers, two piece elbows, tees, valve and flange covers, etc., with a 1 mil polykraft or acrylic vapor barrier.



4. ADJ-3b: 0.020 inch thick aluminum jacket conforming to ASTM B-209 with a 3 mil factory applied polykraft moisture barrier. Longitudinal joints shall be placed at the side of the pipe facing downward at either the 4 o'clock or 8 o'clock position so as to shed water. Aluminum fitting covers, two piece elbows, tees, valve and flange covers, etc., with a 3 mil polykraft or acrylic vapor barrier.
  5. ADJ-4: 20 mil PVC jacket suitable for all types of paint. Similar to Manville Zeston 25/50.
  6. ADJ-5: shall be a Cell-Co plastic jacket with the following color coded pattern:
    - a. Steam (HP/LP): White
    - b. Condensate (Pump/Gravity): White
    - c. Hot Water: Orange
    - d. Chilled Water: Blue
    - e. Vent: Black
    - f. City Water: Gray
    - g. Other: Yellow-green
  7. ADJ-6 A finish jacket of an Asbestos-free and woven as high temperature, heat-resistant fabric. Lagging Cloth having a treated weight of 24 oz./sq.yd. Material shall be suitable for a sustained operation at 1100°F. Calcium silicate piping for generator exhaust piping shall also be jacketed with corrugated aluminum.
  8. ADJ-7: 0.16-inch thick type T-316 stainless steel jacket. Alloys conforming to ASTM A-240. System shall have a 3-mil polykraft vapor barrier.
- F. Adhesives:
1. Code ADH-1: Fibrous adhesive, non-flammable, quick setting adhesive for calcium silicate. Similar to Childers CP-97, 98.
  2. Code ADH-2: Fast-drying vinyl base coating and lagging adhesive. Similar to Childers CP-50A HV2.
  3. Code ADH-3: Fast-drying neoprene base adhesive for lap joints of foil-faced facing applied over pipe insulation. Similar to Childers CP-82.
  4. Code ADH-4: Adhesive for use in adhering fiberglass board or blanket insulation to pipe and equipment. 3M Company Insulation Adhesive No. 35 or 38 non-flammable adhesive.
- G. Caulking components:
1. Code CC-1: For use with foam glass and/or joint sealant applications. Flexible elastomeric vapor barrier sealant. Similar to Childers CP-76.
- H. Mastics:
1. Code MAS-1: Vapor barrier mastic made with an elastomeric resin. For indoor use. Similar to Childers CP-30.
  2. Code MAS-2: A non-water vapor barrier asphaltic emulsion coating, breathing type, for above ground installations. Similar to Childers CP-10.
  3. Code MAS-3: Vapor barrier mastic made with an elastomeric resin. For outdoor use.
- I. Tie wire:
1. Tie wire for securing insulation in place shall be type 304 stainless steel annealed steel wire of gauge and proper spacing as recommended by the insulation manufacturer. Wire shall be drawn up tightly enough to become embedded in the insulation and the ends of the loop twisted, bent over, and pressed into the insulation so as to leave no ends protruding.
- J. Banding:
1. 3/8 inch x 0.02 inch type 304 stainless steel for pipe insulation.
  2. 3/4 inch x 0.02 inch type 304 stainless steel for additional insulation jackets.

- K. Wire mesh:
  - 1. Wire mesh shall be one inch by No. 20 BGW hexagonal mesh galvanized.
  - 2. Expanded metal: Expanded metal shall be 1/2 inch Hi-Rib metal lath of copper bearing steel.
  
- L. Tape:
  - 1. Lead foil tape shall be 3M Company Lead Foil Tape No. 422, 4 mil thick, acrylic adhesive, 2 inch wide.
  - 2. Vinyl plastic tape, silver gray, flame resistant, vapor barrier sealant tape on rigid and flexible insulation material for warm or cold air ducts. Similar to 3M Company Duct Sealing Tape No. 474.
  - 3. Aluminum foil tape, dead soft aluminum foil, point seal on stick pin, metal patching, moisture barrier, heat reflecting and general sealing on aluminum facing foil. Similar to 3M Company Aluminum Foil Tape No. 425.
  
- M. Staples:
  - 1. Staples shall be galvanized clad outward clinching insulation staples.
  
- N. Insulating cement:
  - 1. Insulating cement shall be a mineral-fiber (wool) ASTM C 195 base material having essentially the same insulating characteristics as the adjacent insulation. Similar to PABCO High Temperature Insulating Cement. Insulating cement shall be applied in layers to a maximum thickness of 1/2 inch at one time. Each layer shall be allowed to dry thoroughly before subsequent layers are applied.
  
- O. Finishing cement:
  - 1. Finishing cement ASTM C 449 shall be diatomaceous silica thermal insulating materials with a suitable proportion of heat resistant binder, hydraulic setting insulating cement capable of withstanding maximum temperature of 700 degrees Fahrenheit. When mixed with water it shall be a plastic mix suitable for trowel applications and shall present a hard, smooth and durable surface after drying. Similar to PABCO No. 127.
  
- P. Combination insulating and finishing cement:
  - 1. Similar to Ryder One Coat or equal.
  
- Q. Welding studs:
  - 1. Welding studs shall be capacitor type split pin or TCP tipped insulation pins with speed clips. Similar to Nelson Stud Welding Spec. 28.

### **PART 3 – EXECUTION**

#### **3.01 PREPARATION**

- A. No insulation shall be applied until the surfaces of the equipment to be insulated are thoroughly cleaned and until pipes and equipment to be insulated have been leak tested and proven tight and accepted by THE ENGINEER
  
- B. Insulation shall not be applied to piping or equipment until authorization is given to the Contractor by THE ENGINEER. Contractor shall submit a request for authorization. If any insulation is applied without first obtaining authorization, it will be the Contractor's responsibility to remove the insulation and apply it again if so directed.

- C. Ensure surface is clean and dry prior to installation. Ensure insulation is dry before and during application. Finish with systems at operating conditions.
- D. The execution of the insulation work shall be in strict accordance with the best practices of the trade and with the specifications.
- E. The insulation shall be handled and applied in a manner that will not adversely affect its structural or insulating properties.
- F. The installation instructions provided by the insulation material manufacturer of all materials specified in this Section shall be followed when installing these materials. Where the specifications are in conflict with manufacturers' instructions, such conflicts shall be brought to the attention of the ENGINEER for a decision.
- G. Welding operations will not be permitted on certain specific items of equipment, piping and components for the application of studs, pins, support rings, angles, etc. Contractor shall obtain permission in writing from THE ENGINEER to perform any welding.

### 3.02 PIPING INSULATION INSTALLATION

- A. Ensure insulation is continuous through interior walls. Pack around pipes with fire proof self-supporting insulation material, fully sealed. Insulation on all cold surfaces where vapor barrier jackets are specified must be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors, and other heat conductive parts that are secured directly to cold surfaces must be adequately insulated and vapor sealed to prevent condensation.
- B. Insulate fittings, valves, unions, flanges, and strainers. Do not insulate flexible connections and expansion joints. Terminate insulation neatly with PVC or aluminum end caps.
- C. Premolded fiberglass insulation for straight pipes shall be applied, neatly fitted around piping and sealed with adhesive ADH-3. Adhesive shall be applied to only one side of each joint and shall not be applied to the pipe surface.
- D. Where two sections of pipe insulation butt together provide a 3 inch wide butt strip of same facing material as adjacent insulation facing. Adhere neatly in place using adhesive ADH-3.
- E. All pipe elbows shall be insulated with short radial and mitered pieces of board or block insulation or premolded pieces of pipe insulation. Each piece shall be butted tightly against the adjoining piece and all joints, seams, voids and irregular surfaces shall be filled with insulating cement finished to a smooth, hard and uniform contour. Coat with MAS-1 mastic and reinforce with ADJ-2 additional jacket. In addition, place a fitted PVC cover (ADJ-4) over insulated elbow exception. Tape elbow to adjoining insulation.
- F. All valves and fittings shall be insulated with premolded fittings, sectional pipe insulation, or blocks of the same material and thickness as used for the adjacent pipe. Flange insulation shall overlap the adjoining pipe insulation by not less than the thickness of the pipe insulation. Sectional pipe covering or block insulation shall be cut to fit, and each section butted closely to the next and held in place with tie wire.
- G. Fittings on pipe lines in finished and concealed areas shall be covered with premolded fiberglass pipe fitting insulators Insul-Coustic or equal, where sizes are available, otherwise, use mitercut segments of molded pipe insulation, wire in place with joints and raw edges sealed with adhesive and smoothed out with a coat of insulating cement.

- H. On cold pipes the fittings shall be finished with (2) coats of an approved vapor barrier mastic, reinforced with glass cloth extending 2 inches onto adjacent pipe insulation. Hot pipes shall be finished in a similar manner except the mastic need not be of the vapor barrier type.
- I. Insulation shall cover the entire surface of the fittings and bodies of the valves up to and including the bonnets, and to the valve stuffing box studs, bolts, or nuts. All joints, seams, and irregular surfaces shall be filled with insulating cement. The insulated surfaces shall be covered with a 1/4 inch thick layer of finishing cement and heavily coated with vapor barrier mastic MAS-1 for cold services and mastic MAS-2 for hot services and reinforced with ADJ-2 additional jacket. Mastic shall be trowelled to a smooth and well-shaped contour compatible with adjoining pipe insulation jackets as specified.
- J. Use ADJ-4 covers over fittings and flanges everywhere except when ADJ-3a, ADJ-3b, or ADJ-5 is specified.
- K. Repair separation of joints or cracking of insulation due to thermal movement or poor workmanship on all joints of all piping.
- L. All instrument connections for thermometers, thermocouples, gauges, test connections, flow meters, etc., on insulated pipes, vessels, or equipment shall be insulated. The insulation shall be shaped at these connections by tapering it to and around the connection with insulating cement and finishing with finishing cement, vapor barrier adhesive, applicable mastic, or caulking compound.
- M. Where removable flange and valve insulation is required or specified, installation shall conform to the following:
  - 1. Removable flange insulation shall be made from sectional pipe insulation of the same thickness as that on the adjoining pipe or from block insulation 1/2 inch thinner than the pipe insulation and finished with insulating cement. Insulation jackets shall be the same as adjoining pipe insulation unless indicated otherwise.
  - 2. When flange covers are made from sectional pipe insulation, they shall enclose the flanges and be long enough to extend at least 2 inches over the adjacent pipe insulation on each side of the flange. The space between the flange cover and the pipe insulation shall be filled with insulating cement. Secure the flange cover in place with stainless steel banding.
  - 3. When flange covers are made from block insulation, they shall be made in two halves. Each half shall consist of mitered blocks wired to 1/2 inch galvanized hardware cloth mesh. This wire frame, with its attached insulation, shall then be secured to the flanges with tie wire. The insulation cover shall be long enough to extend at least 2 inches over the adjacent pipe insulation on each side of the flange. The space between the flange cover and the pipe insulation shall be filled with insulating cement. The whole flange cover assembly shall be finished with 1/2 inch of insulating cement applied in two coats.
    - a. After the first coat is dry, the second coat shall be trowelled to a smooth hard finish. All surfaces shall then be finished with jackets as specified in the schedule.
  - 4. Removable valve insulation covers shall be constructed in the same manner as for flanges with the following exception; the two part section shall be divided on the vertical center line of the valve body, bonnet, flange or joint.
  - 5. When specified to insulate the complete valve, the hand wheel or lug wrench shall be removed to accommodate the valve bonnet box. The valve bonnet box shall be constructed in a one piece closure, one end closed, one end opened to fit up to the valve body insulation. Securing the valve and bonnet box sections, sealing and pointing of the insulation shall be done in same manner as specified for flange covers.
  - 6. Unless indicated as removable, a permanent installation as previously specified shall be used.

7. Protect insulation on piping 2 1/2" and up where supported in hangers by means of calcium silicate rigid pipe insulation or jackets. Saddles or shaped galvanized steel pieces approximately 10" long by half the circumferences of insulated pipe.
8. All piping shall have been tested and approved prior to installation of insulation.
9. All piping or surfaces where subject to condensation on the outside shall be insulated including vaporseal finish.

**PART 4 – SCHEDULES**

4.01 PIPING INSULATION SCHEDULE: (ASJ = "All-Service-Jacket")

| Service   | Type Insulation and Thickness (Inches) | Facing     | Additional Jacket* |
|---|--|------------|--------------------|
| Hot Water Heating, Up to 2" 2 1/2" & Up         | Molded Fiber Glass<br>1 1/2<br>2       | ASJ<br>ASJ |                    |
| Condensation Drains & Vents, Cold Water Make-up | Molded Fiber Glass<br>1                | ASJ        |                    |
| Others not scheduled                            | Molded Fiber Glass<br>1                | ASJ        |                    |

1. \*Including elbows, fittings, valves, complete system.

- A. Provide vapor barrier on all cold water and rainwater piping.

**END OF SECTION 23 07 19**

## SECTION 232000 – HVAC PIPING AND JOINTS

### PART 1 – GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

#### 1.02 WORK INCLUDED

- A. Furnish and install piping, fittings, flanges, unions, bolting, gaskets, welding, and threading for all main piping network, branches and connections to all fuel fired HVAC and electrical equipment and systems to make complete and operations systems.
- B. All systems shall be installed in accordance with local code including vent piping and relief discharge termination points.
- C. Secure all permits and local/state approvals for the installation of all components included under this Section.

#### 1.03 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

#### 1.04 REFERENCES

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.
- B. ASME: American Society of Mechanical Engineers
- C. ANSI: American National Standards Institute
  - 1. A13.1: Scheme for Identification of Piping Systems
  - 2. B16.1: Cast Iron Pipe Flanges and Flanged Fittings
  - 3. B16.3: Malleable Iron Threaded Fittings
  - 4. B16.4: Cast Iron Threaded Fittings
  - 5. B16.5: Pipe Flanges and Flanged Fittings
  - 6. B16.9: Factory Made Wrought Steel Butt Weld Fittings
  - 7. B16.11: Forged Steel Fittings, Socket Weld and Threaded
  - 8. B16.15: Cast Bronze Threaded Fittings
  - 9. B16.18: Cast Copper Alloy Solder Joint Pressure Fittings
  - 10. B16.20: Metallic Gaskets for Pipe Flanges
  - 11. B16.21: Non Metallic Flat Gaskets for Pipe Flanges
  - 12. B16.22: Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
  - 13. B16.24: Cast Copper Alloy Pipe Flanges and Flanged Fittings Class 150, 300, 400, 600, 800, 1500 and 2500
  - 14. B182.1 Square and hex bolts and screws

15. B182.2 Square and hex nuts
16. B16.39: Malleable Iron Threaded Pipe Unions
17. B16.42: Ductile Iron Pipe Flanges and Flanged Fittings
18. B31.1: Power Piping
19. B31.9: Building Services Piping
20. B36.10: Welded and Seamless Wrought Steel Pipe
21. Z49.1: Safety in Welding and Cutting

D. AWWA: American Waterworks Association

1. C104/A21.4: Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water
2. C110/A21.10: Ductile Iron and Gray Iron Fittings for Water
3. C111/A21.11: Rubber Gasket Joints for Ductile Iron Pipe and Threaded Flanged
4. C151/A21.51: Ductile Iron Pipe, Centrifugally Cast in Metal Molds or Sand Lined Molds, for Water or Other Liquids
5. C153/A21.53: Ductile Iron Compact Fittings, 3" thru 6", for Water and Other Liquids
6. C200: Steel Water Pipe 6" and Larger
7. C205: Cement Mortar Protective Lining and Coating for Steel Water Pipe
8. C206: Field Welding of Steel Water Pipe
9. C207: Steel Pipe Flanges for Waterworks
10. C208: Dimensions For Fabricated Steel Water Pipe Fittings
11. C600: Standard for Installation of Ductile Iron Water Mains and Their Appurtenances
12. C606: Standard for Grooved and Shouldered Joints
13. C210: Liquid Epoxy Coating System for the Interior and Exterior of Steel Water Pipes

E. ASTM: American Society for Testing and Materials

1. A 47: Ferritic Malleable Iron Castings
2. A 53: Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
3. A 74: Cast Iron Soil Pipe and Fittings
4. A 105/A105M: Forgings, Carbon Steel, for Piping Components
5. A 106: Seamless Carbon Steel Pipe for High-Temperature Service
6. A 135: Electric-Resistance-Welded Steel Pipe
7. A 153: Zinc Coating (Hot Dip) on Iron and Steel Hardware
8. A 183: Carbon Steel Track Bolts and Nuts
9. A193: Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
10. A194: Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
11. A197: Cupola Malleable Iron
12. A 234/A234M: Pipe Fittings of Wrought Carbon Steel and Alloy / Rev A: Steel for Moderate and Elevated Temperature
13. A 307: Carbon Steel Bolts and Studs, 60000 PSI Tensile Strength
14. A 312: Standard for Seamless and Welded Austenitic Stainless Steel Pipe.
15. A 536: Ductile Iron Castings
16. A 568: Steel, Sheet Carbon and High-Strength Low-Alloy / Rev A: Hot-Rolled and Cold-Rolled, General Requirements
17. A 795: Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
18. B 32: Solder Metal
19. B 43: Seamless Red Brass Pipe, Standard Sizes
20. B 75: Seamless Copper Tube
21. B 88: Seamless Copper Water Tube
22. C 564: Rubber Gaskets for Cast Iron Soil Pipe and Fittings
23. D 2000: Standard Classification System for Rubber Products in Automotive Application

24. F 36: Compressibility and Recovery of Gasket Materials
25. F 37: Sealability of Gasket Material
26. F 38: Creep Relaxation of a Gasket Material
27. F 146: Fluid Resistance of Gasket Materials
28. F 104: Non-metallic Gasket Materials
29. F 152: Tension Testing of Nonmetallic Gasket Materials
30. C 33: Standard Specification for Concrete Aggregates
31. D-2122: Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
32. D-2513: Standard Specification for Thermoplastic Gas Pressure / Rev. B: Pipe, Tubing and Fittings
33. D-1248: Standard Specification for Polyethylene Plastic Molding and Extrusion Materials
34. D-3350: Polyethylene Plastic Pipe and Fittings Materials

F. Copper Development Association

#### 1.05 SUBMITTALS

- A. See Section 232000 and General Conditions for additional information.
- B. Product Data: Include data on pipe materials, steam/condensate specialties, pipe fittings and accessories. Provide manufacturers catalogue information and mill certificates.
- C. Welders Certificate: Include welder's certification of compliance with ASME (BPV IX).
- D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- E. Project Record Documents: Record actual locations of all piping, valves, traps and valve tag numbers.
- F. Grooved joint couplings and fittings shall be shown on drawings and product submittals and shall be specifically identified with the applicable designation.
- G. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- H. Provide piping plans to a minimum scale of ¼" - 1'-0".

#### 1.06 QUALITY ASSURANCE

- A. Installer: Company specializing in performing work of the type specified in this section, with documented experience.
- B. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
- C. Welders: Certify in accordance with ASME (BPV IX).

#### 1.07 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 for installation of hydronic piping systems including specialties.



- B. Welding Materials and Procedures: Conform to ASME (BPV IX) and applicable state labor regulations.
- C. Provide certificate of compliance from authority having jurisdiction, indicating approval of welders.

1.08 DELIVERY, STORAGE AND HANDLING

- A. Protect piping systems and specialties from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.09 ENVIRONMENTAL

- A. Do not install piping when environmental conditions are outside the specific limitations of the referenced codes and manufacturer's recommendations.

**PART 2 – PRODUCTS**

2.01 GENERAL

- A. Provide all piping, fittings, flanges, couplings, unions, bolting, gaskets, welding, threading and soldering for main piping network, branches and connections to equipment as shown on the drawings and as required to provide complete systems. All piping, fittings and accessories shall conform to the appropriate Service Pipe Schedule as specified hereinafter.

- 1. Acceptable manufacturers contingent on compliance with the specifications.

- a. Pipe

- 1) Steel

- a) U.S. Steel
- b) AK Steel

- 2) Ductile Iron

- a) U.S. Pipe
- b) Atlantic Pipe

- 3) Copper

- a) Cambridge Lee
- b) Cerro

- b. Fittings

- 1) Welded Fittings

- a) Anuil
- b) Weld Bend
- c) Hackney

- 2) Iron Fittings
  - a) ITT Grinnel
  - b) Flagg
  - c) Ward
  
- 3) Steel
  - a) Vogt
  - b) Velan

B. General

1. All pipe and fitting shall be new, first quality material suitable for continuous operation under the conditions specified. All material shall be in conformance with ANSI Standards.
2. All pipe shall be a product of the United States of America. Mill certificate shall be provided as required.
3. All piping shall be clearly marked with material specification.
4. All steam and condensate system pipe and material shall comply with the requirements and recommended practices of ASME B31.1 Power Piping Code (latest Edition and Addenda).
5. All hydronic system pipe and material shall comply with the requirements and recommendation practices of ASME B31.9 Building Services Piping (latest Edition and Addenda).
6. Elbows shall be long radius ANSI B16.9 unless otherwise specified.
7. Fittings shall be used at all branch connections from headers.
8. Acceptable fittings shall be tees. "Weldolets", "Threadolets" and "Sockolets" will also be allowed as specified. Fishmouth or shaped nipples will not be allowed.
9. Provide drains at low points and vents at high points of all piping systems and between pumps and check valves.
10. Steam pipes shall be provided with drip legs and traps at all low points and as otherwise specified.
11. Steam service as specified herein shall include steam trap piping to and including shut-off valve on trap discharge and relief valve discharge.
12. Condensate service shall start at the connection to the main valve where the branch to the steam trap starts.
13. Lubricants used for the installation of grooved couplings shall be approved by the coupling manufacturer.
14. All pipe and fittings with threaded ends shall have IPS threads cut clean and true and in conformance with the ANSI B1.20.1.
15. Threaded pipe and fittings shall be made up with special care to avoid marring or damaging pipe and fitting surfaces.
16. All threaded joints in steel and iron pipe shall be made up with pipe thread compound or other compound suitable for design temperature and pressure of piping. All threaded joints in copper pipe shall be made up with Teflon pipe tape, petroleum gas grade, wound on male threads, clockwise as viewed from end of pipe.
17. Provide high temperature brass, bronze steel or cast ductile iron (as appropriate) dielectric unions or flanges between dissimilar pipe materials to prevent galvanic action, as required. Gaskets shall be suitable for operation up to design temperature of the piping.
18. No joints shall be "backed-off" to align pipe and fittings.
19. Gauge lines shall be stainless steel with compression fittings.
20. Piping for compressed air for controls shall be copper.

21. Use "Never-Freeze" Copper Anti-Seize by Frederickseal or similar on all flange bolts. Torque all bolts to suitable values using torque wrenches.
22. All condensate piping and steam piping in inaccessible shafts, trenches, or tunnels shall be socket weld 2" and below.

2.02 SERVICE PIPE SCHEDULE

| Service   | Type                        | Grade    | Wall   |                   | Joints (Minimum Sch. Shall match Wall) |             |
|---|-----------------------------|----------|--------|-------------------|--|-------------|
|   |                             |          | to 10" | 12" & Up          | 2" and Less                            | 2½" & Up    |
| Hot water supply and return                           | A106 or A53 Seamless or ERW | A or B   | Sch.40 | Standard 0.375"   | Threaded (Note 1)                      | Butt Welded |
| Miscellaneous drains 2½" & up (up to 150F on grooved) | A53                         | A or B   | Sch.40 | Standard 0.375"   |  | Butt Welded |
| Miscellaneous drains to 2"                            | Hard Drawn Copper           | ASTM B88 | Type L |                   | DWV 95-5 Solder                        |             |
| Other piping (up to 150F on grooved)                  | A106 or A53 Seamless or ERW | A or B   | Sch.80 | Extra Strong 0.5" | Threaded Malleable                     | Butt Welded |

**Note 1:** For chilled and hot water piping less than 2-1/2" pipe size, Contractor may use Type L copper with 95-5 solder joints, in lieu of steel pipe with threaded joints.

2.03 FITTINGS

A. For Steel Pipe

1. 2 1/2" and Larger, Butt Welded
  - a. Butt weld, same weight as piping.
  - b. ANSI A234 WPB
  - c. ANSI B16.9
  - d. Branch Connections:
    - 1) Equal to main and to (2) pipe sizes smaller shall be welded tees.
    - 2) Three (3) pipe sizes and smaller than main:
      - a) 2 1/2" and larger: weldolets or Tee
      - b) To 2": Thread-O-Lets, sock-o-let or Tee.
2. 2" and Smaller Screwed
  - a. Cast Iron: A126 ANSI B16.1, B16.4
    - 1) 125 lb., wsp
    - 2) 250 lb., wsp where noted
  - b. Malleable Iron: A47, A197, ANSI B16.3
    - 1) 150 lb., wsp. Galvanized for fill and make-up water galvanized piping.
    - 2) 150 lb. wsp.

3) 300 lb. wsp where noted

- c. Carbon Steel: A105, ANSI B16.11
- d. Cast iron drainage: ANSI B16.12
- e. Galvanized for galvanized piping.
- f. Ductile Iron: ASTM A395. Contractor has option to furnish 300 lb. ductile iron in lieu of 250 lb. cast iron or 300 lb. malleable iron.

B. For Copper Tubing

1. Solder Joint: Wrought Copper, ANSI B16.22 or Cast Bronze B16.18.

a. 2" and less

1) Silver brazing alloy.

b. 2½" and larger

1) Silver brazing alloy.

a) For refrigerant piping and where noted: Silver brazing alloy, similar to Handy and Harman Easy-Flo.

2. Compression and Flared Fittings: Cast brass, ANSI B16.26.

C. For Red Brass Pipe: Standard cast bronze, banded, threaded, ANSI B16.15.

2.04 FLANGES

A. For Steel Pipe

1. Welded: Weld neck, ANSI B16.5.

- a. 150 lb. Wsp
- b. 300 lb. Wsp
- c. 400 lb. Wsp

2. Screwed

- a. Standard Cast Iron: ANSI B16.1
- b. Extra Heavy Cast Iron: ANSI B16.1

3. Match connecting flange class and facing.

2.05 FLANGE GASKETS

A. One-piece ring type 1/16" thick, except as noted.

B. Suitable for temperature, pressure and service of system.

C. Compressed compound fiber type for the following:

1. Low pressure steam and condensate return and pumped discharge.

2. Hot water.
3. Cold water.

D. Spiral wound Type 304 stainless steel with flexible graphite fill for:

1. Media and High Pressure Steam systems.
2. Condensate systems.

E. For Joints of Dissimilar Metals

1. Isolating gaskets, sleeves, and washers between flanges, bolts and nuts.
2. Gaskets, similar to DuPont Teflon.

## 2.06 UNIONS

A. For Steel Pipe

1. Malleable iron 300 lb. Wsp
  - a. Ground Jacket Seat: Brass-to-iron, black or galvanized to match piping.
2. Forged steel, 2000, 3000 lb. WOG class, bronze-to-steel or steel-to-steel seats, where noted or required for service.
3. Unions are not required on installations using grooved connections. The couplings shall serve as unions.

B. For Red Brass Pipe

1. All bronze, 150 lb. wsp, ground joint seat.

## PART 3 – INSTALLATION

### 3.01 PIPING INSTALLATION

- A. Provide all piping systems as shown on the drawings and otherwise required to make a complete, workable and neat job, installing all valves, appurtenances, grooved joint couplings, unions and gaskets. The Contractor shall use care arranging all piping as shown on the drawings and shall carefully examine the arrangements where offsets are indicated and shall follow details as shown.
- B. All piping shall be run to true alignment generally parallel or perpendicular to adjacent building walls, floors and ceilings and with uniform grades and spacing so as to present a neat and workmanlike appearance.
- C. Care shall be paid to the exact locations for all piping and equipment with respect to equipment, ducts, conduits, slabs, beams and lighting fixtures, so as to provide maximum access to all mechanical and electrical equipment in the buildings. Close coordination and cooperation shall be exercised with other Trades in locating the piping and equipment in the best interests of the Owner. The drawings and specifications covering other work to be done in the buildings shall be carefully studied and arrangements made to avoid conflict.

- D. The drawings shall be followed where they are definite and provided such procedure causes no objectionable conditions or does not conflict with other Trades, Laws, Regulations or recommendations of equipment manufacturers. The drawings are intended to indicate the sizes of piping connections and if certain sizes are omitted, or unclear, obtain additional information before proceeding.
- E. Rough in for all equipment requiring connections to the Mechanical work. Obtain all necessary data on exact locations, sizes, connections, fittings and arrangements and exact routings as may be required for proper installation.
- F. Bushings shall not be used for reducers. Reducing fittings shall be used for all changes in pipe size and shall be as follows:
  - 1. Horizontal water piping: Eccentric flat on top for venting.
  - 2. Horizontal steam and condensate piping: Eccentric flat on bottom for drainage.
  - 3. Vertical water or steam: Concentric.
- G. Unions, grooved joint couplings or flanges shall be provided in conjunction with all equipment, coils, control valves and specialties in all pipe lines and at all points necessary to provide reasonable access to the piping systems.
- H. Ends of all pipes shall be reamed clean and all pipes shall be straightened before erection and measures shall be taken to preserve this cleanliness after erection.
- I. Support piping independently at all equipment so that the equipment is not stressed by piping weight or expansion.
- J. Arrange piping for maximum accessibility for maintenance and repair, locate valves for easy access and operation.
- K. Provide dielectric unions, waterway fittings or flanges between dissimilar pipe materials to prevent galvanic action as required.
- L. Provide proper provision for expansion and contraction in all portions of pipe work, to prevent undue strains on piping or apparatus connected. Provide double swings at riser transfers and other offsets to take up expansion. Arrange riser branches to take up motion of riser. Branch runouts to equipment shall have a minimum of (3) elbows, adequately spaced.
- M. All piping connections to equipment shall be made with offsets. Provide with unions, grooved joint couplings and/or flanges so arranged that the equipment can be serviced or removed without dismantling the piping. If equipment, when commissioned, becomes air bound or stratified, all necessary modifications to the piping system required to rectify the condition permanently shall be made to piping and equipment, furring, floors, walls, etc., at the Contractor's expense.
- N. Pipe pitch, unless otherwise indicated on the drawings, shall be as follows:
  - 1. Steam and condensate: 1" in 40'-0", down in direction of flow.
  - 2. Steam riser branches and undripped connections: 1" in 10'-0", up in direction of steam flow.
  - 3. Water Piping:
    - a. Up to 1" pipe: 1" in 40'-0", up in direction of flow.
    - b. 1 1/4" larger: 1" in 100'-0", up in direction of flow.

4. Condensation Drainage:
  - a. Preferred: 1/4 in./ft., down in direction of flow.
  - b. Minimum: 1/8 in./ft., down in direction of flow.
- O. Drain connections at low points in water piping and where noted:
  1. In equipment rooms:
    - a. To 3" pipe: 3/4" ball valve.
    - b. 4" to 8": 1 1/2" ball valve.
    - c. 10" and larger: 2 1/2" ball valve.
  2. Other areas:
    - a. 1/2" ball valve with capped hose connection.
- P. Manual air vents at high points and where required to expel air:
  1. To 3" pipe: line size air chamber, 12" long, 1/2" ball valve.
  2. 4" to 8": line size air chamber, 6" long, 1/2" ball valve.
  3. 10" and larger: line size pipe cap, 1/2" ball valve.
- Q. Copper tubing and galvanized steel shall not be mixed in any one run of piping, except as otherwise specified herein.
- R. During construction, temporarily close open ends of pipes with sheet metal caps or duct tape to prevent debris from entering piping systems.
- S. At low points of steam lines provide traps adequately sized to collect condensate. All supply mains shall be dripped and trapped on any vertical lift. Provide capped full sized dirt pockets at all traps, riser heels, and wherever dirt and scale may accumulate. To meet job conditions, mains shall be set up (with drip connections to return line) to maintain headroom and clear other pipes as hereinbefore specified. System is to be arranged to secure venting of air to the return line at all low points in steam mains, without permitting ingress of air. All apparatus subject to high temperature differentials and high steam demand loads such as steam-water heat exchangers shall have vacuum breakers installed.
- T. Where condensate piping, to meet job conditions, may have to set down under stoops, doors, etc., and again rise after passing these, the sets shall be made with 45° fittings and with Y-laterals at each end, with brass plugs to permit easy cleaning of trapped portions of pipe. At any points where return mains have to rise again, after being depressed, provide overhead "air lines" (not smaller than 1" in size) and connect the (2) high sides. Any turns in water sealed lines shall be made with crosses, with brass plugs in unused outlets to facilitate cleaning.
- U. Joints in piping systems, for all services, shall be made tight and leakproof against test pressures. Leaks in screwed or flanged joints which cannot be eliminated by normal wrench tightening methods shall be repaired at the joint. Under no circumstances shall caulking be allowed. No joints shall be backed off to align pipe fittings.
- V. Provide extra heavy pipe for nipples where unthreaded portion of pipe is less than 1 1/2" long. Use of close nipples is not permitted.

### 3.02 WELDING

- A. All welding done under this Contract shall be performed by experienced welders in a neat and workmanlike manner. All welding of steam and condensate piping shall be in accordance with ASME B31.1 Power Piping Code (latest Edition and Addenda). All welding of hydronic system piping shall be in accordance with ASME B31.9 Building Services Piping (latest Edition and Addenda). The Contractor shall furnish to the Owner for approval and record the following:
1. Welding Procedure Specifications (WPS) for each procedure to be used
  2. Procedure Qualification Record (PQR)
  3. Welding Operator Qualification Tests (WPQ) for each welder to be employed.
- B. Documents shall be on forms similar to the forms referenced in the ASME Boiler & Pressure Vessel Code, Section IX, latest edition. These records shall be furnished to the Owner for this project not less than (2) weeks, prior to any welding. All welders to be employed by the Contractor on this work shall be certified in accordance with the above. The Mechanical Contractor shall test welders to these procedures within (3) months of the work beginning to certify them for this work. The above forms shall be clearly marked specifically for the Contractor's use and certified by the appropriate personnel. Documents prepared for other's use are not allowed. Failure to provide these forms to the satisfaction of the Owner, or his representative, will result in the replacement of the Mechanical Contractor with one who can meet these requirements, at no additional cost to the Owner. No delays or cost increases to the overall project schedule will be accepted due to non-compliance with the above by the Mechanical Contractor.
- C. Mitered elbows are not permitted. Odd angle elbows shall be cut from long radius elbows.
- D. The weld reinforcement shall be not less than 1/16" nor more than 1/8" above the normal surface of the joined sections. The reinforcement shall be crowned at the center and shall taper on each side to the surface being joined. The exposed surface of the weld shall present a workmanlike appearance and shall be free of depressions below the surface of the joined members.
- E. No welding of any kind shall be done when the temperature of the base metal is lower than 50°F. Material to be welded during freezing temperatures shall be made warm and dry before welding is started. Temperature of metal shall be "warm to the hand", or approximately 60°F.
- F. Welds will be inspected visually by supervisory representatives of the Architect and the Contractor. Any weld judged defective by the Architect from a visual inspection shall be cut out and tested in the presence of the Owner or his representative. In the event any welder consistently produces a high percentage of unsatisfactory production welds, he shall be discharged at the request of the Owner, even though he is able to produce satisfactory welds when especially tested. Removal and replacement of test coupons and samplings shall be done at the expense of the Contractor. The Owner reserves the right to ultrasonically or radiographically test any welds for full penetration.
- G. Paint all external surfaces of welds with a high temperature paint prior to insulation being applied.
- H. Store all 7018 electrodes in rod oven once original container is opened.



3.03 CLEANING AND BLOWING OUT

- A. The equipment and piping installed under this Section shall be blown out under pressure and cleaned of foreign matter, through temporary connections where necessary, before the system is placed in service. Super heated high pressure steam piping shall be blown out following ASME procedures. Precautions shall be used to prevent foreign matter from getting into equipment and piping during construction. The supplier of water treatment equipment and chemicals shall recommend and furnish chemicals for the purpose of cleaning and blowing out of all systems. All chemicals, materials, instruments and labor shall be provided by the Contractor.
- B. The surfaces of all equipment and piping shall be clean upon completion of the work.
- C. All pipe line strainers shall be cleaned immediately before being turned over to the Owner for acceptance.
- D. During cleaning process, hammer welds to remove scale, weld slag and other debris.

3.04 TESTING

- A. Furnish all labor, material, instruments, supplies and services and bear all costs for the accomplishment of the tests herein specified. Correct all defects appearing under test and repeat the tests until no defects are disclosed; leave the equipment clean and ready for use.
- B. Perform all tests other than herein specified which may be required by Legal Authorities or by Agencies to whose requirements this work is to conform.
- C. Furnish all necessary testing apparatus, make all temporary connections and perform all testing operations required, at no additional cost to the Owner.
- D. All equipment and piping installed under this Contract shall be tested and found tight. Insulated or otherwise concealed piping shall be tested before being closed in. All leaking joints shall be corrected, retested and found tight. Such tests shall conform to the requirements of Local Codes but shall not be less than the equivalent of the tests called for herein. Threaded joints that leak shall not be seal-welded to correct leakage.
- E. Tests performed shall not relieve the Contractor of his responsibility for leaks which may develop after the tests are made.
- F. All piping systems shall be subjected to a hydrostatic test at 1 1/2 times operating pressure measured at the highest point in the system, for a period of (4) hours without drop in pressure.
- G. Tests of piping systems shall be conducted before connections to equipment are made and before piping is covered, buried or otherwise concealed.
- H. Systems found to have leaks shall be subjected to further tests when faulty joints have been repaired or replaced.
- I. Welded joints shall be subjected to a hammer test while under pressure.

**END OF SECTION 23 20 00**

## SECTION 233100 – SHEET METAL WORK AND ACCESSORIES

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

#### 1.02 WORK INCLUDED

- A. Furnish and install a complete system of air distribution, including accessories, to all areas indicated on the contractor drawings.
- B. Create, coordinate and submit ¼" scale Coordination Drawing in accordance with Section 230500.
- C. Provide all ductwork, fittings and accessories to make a complete and operational system in all respects.

#### 1.03 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

#### 1.04 REFERENCES

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.
- B. Material standards shall be as specified or detailed hereinafter and as follows:
  1. ASTM A 36/A 36M – Standard Specification for Carbon Structural Steel.
  2. ASTM A 1008/A 1008M – Standard Specification for Steel, Sheet, Carbon, Cold Rolled, Commercial Quality.
  3. ASTM A 1011/A 1011M – Standard Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip, Commercial Quality.
  4. ASTM A 653/A 653M – Standard Specification for Steel Sheets, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot Dip Process.
  5. ASTM A 666 – Standard Specification for Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
  6. ASTM B 209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
  7. ASTM B 209M – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
  8. ASTM C 443 – Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
  9. ASTM C 443M – Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets (Metric).
  10. NFPA 90A – Installation of Air Conditioning and Ventilating Systems.
  11. NFPA 90B – Installation of Warm Air Heating and Air Conditioning Systems.

12. NFPA 96 – Installation of Equipment for the Removal of Smoke and Grease-laden Vapors from Commercial Cooking Equipment.
13. SMACNA (LEAK) – HVAC Air Duct Leakage Test Manual.
14. SMACNA (DCS) – HVAC Duct Construction Standards – Metal and Flexible.
15. UL 181 – Factory-Made Air Ducts and Connectors.

#### 1.05 SUBMITTALS

- A. See Section 230500 and General Conditions for additional requirements.
- B. Product Data: Provide data for duct materials, duct connectors and all accessories. Include sound attenuator test data in accordance with ASTM E477.
- C. The Sheet Metal Contractor shall submit duct fabrication standards and methods of installation, in compliance with SMACNA and these specifications, for review and approval by the Architect, clearly indicating the combination of metal gauges and reinforcement intended for use for each pressure classification. Duct fabrication shall not be allowed until a satisfactory review of this Standard has been performed and fabrication drawings have been reviewed and coordinated. MERELY SUBMITTING COPIES OF THE SMACNA PRESSURE CLASS TABLES DOES NOT COMPLY WITH THIS REQUIREMENT.
- D. Provide scaled ductwork fabrication drawings. Fabrication drawings shall be double line and as a minimum include elevations, dimensions, sizes, all offsets rises and drops, air distribution devices.
- E. Provide scaled ductwork coordination drawings for all floors and systems in accordance with Section 230500, Submittals.
- F. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA– HVAC Air Duct Leakage Test Manual.
- G. Manufacturer's Installation Instructions: Indicate special procedures for glass fiber ducts.
- H. Manufacturer's Certificate: Certify that installation of glass fiber ductwork meet or exceed recommended fabrication and installation requirements.
- I. Project Record Documents: Record actual locations of ducts, duct fittings and all accessories. Record changes in fitting location and type. Show additional fittings used.

#### 1.06 QUALITY ASSURANCE

- A. All ducts and fittings shall be manufactured by a sheet metal fabrication company whose primary business experience is the manufacture of commercial and industrial quality ducts and fittings. Sheet Metal Contractor shall have adequate experience of building ductwork of the types required for this project as well as successful experience with projects of similar scope. Bids from sheet metal shops which do not meet the specified requirements shall not be acceptable.
- B. **No Ductmate, Ward, Nixon or similar factory made slip-on connections will be permitted.**

1.07 ENVIRONMENTAL REQUIREMENTS

- A. Do not install duct sealants when temperature is less than those recommended by sealant manufacturers.
- B. Maintain temperatures within acceptable range during and after installation of duct sealants.

**PART 2 - PRODUCTS**

2.01 SHEET METAL WORK

A. General

1. Acceptable Manufacturers (Provided they are in compliance with these specifications)

a. Sheet Metal

- 1) All ducts and fittings shall be manufactured by a sheet metal fabrication company whose primary business experience is the manufacture of commercial and industrial quality ducts and fittings. Sheet Metal Contractor shall have adequate experience of building ductwork of the types required for this project as well as successful experience with projects of similar scope. Bids from sheet metal shops which do not meet the specified requirements shall not be acceptable.

b. Sheet Metal Accessories

- 1) Access Doors
  - a) Ruskin
  - b) Air Balance
  - c) Buckley Associates
  - d) Ductmate
- 2) Flexible Connectors
  - a) Ventlock
  - b) Elgen Manufacturing
  - c) Duro Dyne
  - d) Ventglass
- 3) Flexible Ductwork
  - a) Clevepak Corp.
  - b) Flexible Technologies
  - c) Unaflex Rubber Corp.
  - d) Flexmaster
- 4) Fire Dampers
  - a) Ruskin
  - b) Prefco
  - c) Air Balance
  - d) Greenheck Fan Corp.
  - e) Nailor Industries
  - f) NCA Manufacturing Inc.
- 5) Fire/Smoke Dampers
  - a) Ruskin
  - b) Prefco
  - c) Air Balance
  - d) Greenheck Fan Corp.
  - e) Nailor Industries
- 6) Smoke Dampers
  - a) Ruskin

- b) Prefco
  - c) Air Balance
  - d) Greenheck Fan Corp.
  - e) Nailor Industries
  - 7) Automatic Dampers Airfoil
    - a) Ruskin
    - b) Greenheck Fan Corp.
    - c) Nailor Industries
    - d) T.A. Morrison & Co. Inc. (TAMCO)
    - e) NCA Manufacturing Inc.
  - 8) Balancing Dampers (OBD)
    - a) Ruskin
    - b) Young Regulator
    - c) Prefco
    - d) Greenheck Fan Corp.
    - e) Nailor Industries
    - f) NCA Manufacturing Inc.
  - 9) Small Balancing Damper less than 48x12
    - a) Ruskin
    - b) Young Regulator
    - c) Ventlock
    - d) Duro Dyne
2. Unless otherwise noted, all supply, return and exhaust air ductwork of all types shall be constructed of galvanized sheet metal based on the "Pressure Class" indicated in the "Minimum SMACNA Construction Standards" table found hereinafter.
  3. The drawings are diagrammatic and indicate the arrangements of the principal apparatus, ductwork and piping and shall be followed as closely as possible. Because of the scale of the drawings, it is not possible to show all offsets, rises, drops, rises, fittings, accessories, etc. The Contractor shall carefully investigate the structure, finish conditions, and the work of other trades affecting the work and arrange ductwork, piping, equipment, accessories, etc. accordingly. Provide the best possible arrangement so as to provide the maximum headroom and access to apparatus while providing the minimum resistance to airflow. This work and any extra fittings and offsets required shall be included in the project without extra charge.
  4. In addition to sheet metal ductwork provided under this Contract furnish and/or install accessories and devices furnished by others, including but not limited to smoke detectors. Provide and install miscellaneous sheet metal work including safing, mixing baffles, and blank off panels at unused louver areas.
  5. All duct systems specified to be installed under this Contract, shall conform to the drawings, specifications, Standards, details and recommendations of the latest Edition of SMACNA "HVAC Duct Construction Standards - Metal and Flexible"; and "Round and Industrial Duct Construction Standards" (hereinafter referred to as Duct Manual). Where the requirements under this Section exceed the requirements of the Duct Manual, the specification shall govern. Wherever the word "should" appears, replace with the word "shall".
  6. The Sheet Metal Contractor shall submit duct fabrication standards and methods of installation, in compliance with SMACNA and these specifications, for review and approval by the Architect, clearly indicating the combination of metal gauges and reinforcement intended for use for each pressure classification. Duct fabrication shall not be allowed until a satisfactory review of this Standard has been performed. MERELY SUBMITTING COPIES OF THE SMACNA PRESSURE CLASS TABLES DOES NOT COMPLY WITH THIS REQUIREMENT.

7. All galvanized steel sheet metal shall conform to ASTM A653/A653M (G-90) having not less than 1.25 oz. of zinc on each side of each square foot of sheet. All other duct materials shall be as hereinafter specified as applicable to this Contract.
8. The Sheet Metal Contractor shall install all duct mounted smoke detectors.
9. The Sheet Metal Contractor shall furnish and install all plenums with automatic or manual dampers attached to louvers.
10. The Sheet Metal Contractor shall fabricate and install all canopy hoods, flexible "elephant trunk" exhaust outlets as detailed or noted in the Construction Documents.
11. The Sheet Metal Contractor shall furnish and install exhaust ductwork from emergency generator outlet to exhaust louver including transitions, drains, access doors, flexible connections and baffles to isolate intake from exhaust.
12. There will be no supply and/or return air system ductwork internally lined unless otherwise noted.
13. The Sheet Metal Contractor shall clean and provide temporary caps on all ductwork during installation to prevent dust, dirt and debris from entering ducts during construction, including during shipping, handling and storage in the field.
14. All shop applied fabrication labels shall be applied to the exterior of the ducts. The Sheet Metal Contractor shall remove any material applied to the inside of the ducts before installation.
15. All inline fans shall have companion flanges intake and discharge for removal for servicing.
16. Seal all joints to VAV/VCV/SAV/EV in the field, including reheat coils and sound attenuators.

2.02 DUCT CONSTRUCTION

A. Duct Construction Schedule

| Minimum SMACNA Construction Standards                               |                            |            |               |          |              |       |
|---|----------------------------|------------|---------------|----------|--------------|-------|
| Ductwork Location   | Pressure Class Inches W.G. | Seal Class | Leakage Class | Material | Sound Lining | Notes |
| <b>Non-Laboratory Supply/Return/Transfer</b>                        |                            |            |               |          |              |       |
| Supply from AHU to supply boxes                                     | +6                         | A          | 3             | G-90     | No           | --    |
| Supply from boxes to outlets  | +2                         | A          | 3             | G-90     | No           |       |
| Return from boxes to RF   | -4                         | A          | 3             | G-90     | No           | --    |
| Return from inlets to boxes   | -2                         | A          | 3             | G-90     | No           | --    |
| Return air from RF to AHU   | +3                         | A          | 3             | G-90     | No           | --    |
| Relief Air from RF  | +3                         | A          | 3             | G-90     | No           | --    |
| Supply from FCU to outlets  | ±2                         | B          | 12            | G-90     | No           | 1     |
| Return from inlets to FCU   | -2                         | B          | 12            | G-90     | No           | 1     |
| Transfer ductwork   | ±2                         | B          | 12            | G-90     | Yes          | 1     |
| Linear Supply/Return Grille Plenum                                  | ±2                         | B          | 12            | G-90     | No           | 1     |
| <b>Laboratory Supply/Exhaust</b>                                    |                            |            |               |          |              |       |
| Supply from AHU to outside of shaft at each floor                   | ±6                         | A          | 3             | G-90     | No           | 2     |
| Supply at each floor from shaft to supply air valve or terminal box | ±4                         | A          | 3             | G-90     | No           | 1     |
| Supply from supply air valve or terminal box to room outlet         | ±2                         | A          | 3             | G-90     | No           | 1,4   |
| Lab general exhaust from EAHU to outside of shaft at each floor     | ±6                         |            | 3             | G-90     | No           | 2     |

| Minimum SMACNA Construction Standards  |                            |            |               |               |              |         |
|--|----------------------------|------------|---------------|---------------|--------------|---------|
| Ductwork Location  | Pressure Class Inches W.G. | Seal Class | Leakage Class | Material      | Sound Lining | Notes   |
| Lab general exhaust manifold at each floor from shaft to exhaust air valve or terminal box | ±4                         | A          | 3             | G-90          | No           | 2       |
| Lab general exhaust from general exhaust air valve to room inlet                           | ±2                         | A          | 3             | G-90          | No           | 1,4     |
| Office general exhaust from general exhaust air terminal box to room inlet                 | ±2                         | A          | 3             | G-90          | No           | 1, 4    |
| Fume Hood exhaust system from exhaust fan to exhaust air valve                             | ±6                         | Welded     | 0.5           | 316L S.S.     | No           | 2       |
| Fume Hood exhaust from hood to hood exhaust manifold                                       | -6                         | Welded     | 0.5           | 316L S.S.     | No           | 2,5,6,7 |
| Class II/B2 BSC exhaust from BSC to fume hood exhaust manifold                             | -6                         | Welded     | 0.5           | 316L S.S.     | No           | 2,5,6,7 |
| Snorkel exhaust from snorkel to fume hood exhaust manifold                                 | -6                         | Welded     | 0.5           | 316L S.S.     | No           | 2,5,6,7 |
| Corrosive exhaust from hood to fume hood exhaust manifold                                  | -6                         | Flanged    | 0.5           | 316L S.S.     | No           | 8       |
| <b>Miscellaneous Systems</b>   |                            |            |               |               |              |         |
| General/Toilet exhaust   | -3                         | A          | 3             | G-90          | No           | 1,4     |
| Chemical storage exhaust   | -6                         | Welded     | 0.5           | 316L S.S.     | No           | 2       |
| Exhaust stacks (all exhaust fans)  | +3                         | Welded     | 0.5           | 316L S.S.     | No           | 2,3     |
| Intake and exhaust plenums   | ±4                         | A          | 3             | Same as Ducts | No           | 1,4     |
| Other  | ±3                         | A          | 3             | G-90          | No           | 1,4     |

| Table Notes   |
|---|
| 1 Alternate constructions will be considered provided they are tested in accordance with SMACNA testing standards and approved by the Architect. These tests shall be performed and witnessed by the Architect prior to the submittal of shop standards.  |
| 2 No alternate constructions will be considered.  |
| 3 Exhaust stacks shall be minimum 16 gauge, stainless steel. Refer to Paragraph 2.4 for further definition.   |
| 4 Ductwork in the following locations shall be constructed of aluminum or stainless steel and continuously welded and pitched back (at ¼" per foot) to the outlets, or duct drain.<br>·Within 20'-0" of a shower area exhaust register/grille.<br>·Within 20'-0" of a sterilizer area exhaust register/grille or equipment connection (stainless steel only). |
| 5 Fume hood and Type II/B2 Biosafety cabinet exhaust ductwork shall be 304L S.S. to exhaust manifold.   |
| 6 Refer to Division 11 for connection requirements to equipment.  |
| 7 Exhaust ducts exposed below ceiling shall be 316L stainless steel.  |
| 8 316L Stainless steel duct with fluoro-polymer coating and flanged connections. Refer to Paragraph 2.4 B for further definition.   |

2.03 ADDITIONAL CONSTRUCTION REQUIREMENTS

A. Minimum Requirements

1. The minimum gauge for any steel duct over 2" or under -2" pressure class shall be 24 gauge except when specified heavier.

2. The minimum thickness of any aluminum duct shall be 0.040".
  3. The minimum diameter of any tie rod shall be 1/2".
  4. The maximum tie rod spacing shall be 42" unless specifically engineered in accordance with the SMACNA Industrial Rectangular Duct Standard.
  5. When tie rods intersect, they shall be welded to each other.
  6. No ductwork shall be constructed to less than  $\pm 2$ " w.g. This means nothing is constructed to a standard between  $-2$ " w.g. and  $+2$ " w.g.
  7. **Duct dimensions indicated are clear inside dimensions. The sheet metal dimensions shall be increased to accommodate internal liner where liner is required.**
- B. All joints and seams in all ductwork and casings shall be sealed to SMACNA Seal Class "A". In finished areas, sealing compound shall be neatly applied to exposed ductwork and bands shall be provided over, to cover the sealant.
1. Some SMACNA constructions may not be suitable for the leakage classes specified even though they may meet the pressure class and should not be used.
  2. Seal class A Welded means all welded (i.e. transverse joints, longitudinal seams, spiral seams, fire dampers, volume dampers or any accessories) and in addition it means continuously welded.
  3. All sealants, adhesives and coatings shall be of approved kinds and qualities for each point of application, complying with recommendations for the use and storage.
  4. The method of installation and materials for sealing the ductwork shall be submitted by the Sheet Metal Contractor for review and approval by the Architect, as part of the ductwork construction standards and installation submittal.
- C. All longitudinal seams in all ductwork in excess of  $+2$ " w.g. or less than  $-2$ " w.g. pressure class shall be made with formed Pittsburgh locks.
- D. Grooved seam/flat lock/pipe lock joining methods is restricted to 2" W.G. pressure class only.
- E. Button punch-snap lock seams are not to be used.
- F. Concealed stainless steel ductwork shall have an ASTM mill rolled No. 1 or No. 2 D finish. Exposed stainless steel ductwork shall have an ASTM mill rolled No. 2 B finish, or higher grade as required by the Architect, with all welds ground smooth and final brushed with stainless steel wire brushes. All welds on exposed stainless steel ductwork shall be free of stain, burn-through, or discoloration to the satisfaction of the Architect.
- G. Tie rods shall not be used in any plenum or large duct requiring internal access or use as an access pathway.
- H. All ductwork required to be removable shall be companion flanged SMACNA Type T-22 for ductwork constructed to SMACNA Metal Duct Standard and companion flanged in accordance with Industrial Standards for ductwork required to be constructed to Industrial Standards.
- I. Elbows
1. All dust collection ductwork elbows shall be a centerline radius equal to (2) duct widths or diameters. No reduction shall be allowed.



2. Radius elbows shall be used wherever possible. Where it is impossible or impractical to install a 1.5 times width to centerline radius of elbow (full radius elbow) lesser radii configurations shall be used, each with "radius-proportional" splitter vanes permanently installed within. No radius shall be less than 1.0 times the width. Provide square elbows in rectangular ducts with double thickness vanes with a minimum radius of 4 1/2". Square elbows may only be used when radius elbows will not fit and where specifically approved by the Architect prior to fabrication and/or as required by coordination shop drawings. All offsets shall be of the radius type.
- J. Auxiliary drain pans.
1. Provide 1 1/2" deep auxiliary drain pans under any units with cooling coils located above hung ceilings.
  2. Pans shall be 6" larger than equipment in all directions.
  3. This includes but not limited to all fan coil units.
  4. Drains shall be piped to floor drains or utility sinks.
- K. Ducts Exposed to Weather
1. For all ducts exposed to weather, after all ducts and joints are sealed and tested as specified herein, apply all over and around the same areas of possible leakage (joints), an approved sealer system, so that ductwork outside the building shall be installed in a manner to result in less than 0.5 leakage class.
  2. Exposed ductwork shall be insulated and weather-protected by the Insulation Contractor after the installation is completed and tested.
- L. Provide baffles and/or diffusion plates as required in all air handling units, to ensure proper air mixing, coil velocities and air distribution across filters or coils as determined in the field by the Architect, at no additional cost to the Owner.
- M. It is the intent of this specification to provide a duct system with minimum resistance to airflow. All take-offs shall be throated and transitions made as gradually as possible. "Bullhead" or sharp take-offs shall not be acceptable.
- N. In addition to SMACNA requirements, ductwork in return systems without boxes, ductwork in supply systems without boxes, ductwork in exhaust systems without boxes, ductwork in any Constant Volume System and/or ductwork downstream of VAV Boxes shall be provided with:
1. Volume dampers in all branch takeoffs and in all main branches and ducts of all ductwork systems (supply, return and exhaust) for properly regulating and balancing airflow to all terminal outlets, for all duct sizes, whether shown on the drawings or not. **The above requirement is mandatory.**
- O. All rectangular dampers shall be opposed blade and each shall be controlled by an approved galvanized locking quadrant indicating the damper position, as detailed on the drawings.
1. Volume dampers installed into ductwork that is specified to be externally insulated shall have extended activator/handle rods with extension bracket such that adjustment of the damper handle will not disturb the insulation.
- P. Submit the sheet metal shop drawings to the Balancing Contractor of the project for his review and placement of dampers with the final balancing procedures and requirements in mind.
1. Coordinate the location and areas with the Balancing Contractor, and fabricate the ductwork system accordingly.
  2. Provide any and all balancing dampers required by the balancing contractor at no additional cost.

- Q. In addition to SMACNA requirements, all round ductwork, if used in lieu of rectangular supply and/or return/exhaust systems shall conform to SMACNA.
1. The use of flat oval ductwork shall be acceptable only with prior written approval of the Architect. **Note:** Flat oval shall not be used under negative pressure.
  2. Round duct shall be manufactured of spiral lock seam. Ductwork up to 12"ø and 2" w.g. pressure class can be manufactured with longitudinal lock seams.
  3. All tees shall be conical.
  4. All laterals shall be straight.
  5. All taps through 10" diameter in size shall have a machine drawn entrance and all fittings shall have longitudinal seams, continuous-welded. Both sides of all welds shall be primed with zinc chromate.
  6. All tap entrances shall be free of weld build-up.
  7. Elbows in diameters 3" through 10" shall be 2-section stamped or pleated elbows. Larger elbows shall be gored construction. Elbows shall be fabricated to a centerline radius of 1.5 times the diameter. All gored elbows shall be fabricated according to the following schedule:

| <u>Elbows</u> | <u># of Gores</u> |
|---------------|-------------------|
| Up to 35°     | 2                 |
| 36° to 71°    | 3                 |
| Over 71°      | 5                 |
  8. All field joints in diameters through 48" shall be made with a 2" long slip-fit or sleeve coupling provided assembly is not hindered. Ductwork over 48", and for all sizes where disassembly and removal is required, shall be joined with Vanstone or shop fabricated flanges.
  9. All flanges and taps into spiral ducts shall be factory or shop fabricated and installed as hereinbefore specified. Shipment of loose flanges or taps for field installation shall be avoided.
  10. All access doors for round duct shall be furnished by the access door manufacturer. Round duct access doors shall be of low leakage sandwich type suitable for systems up to 8" pressure, positive or negative. Round duct access doors shall be insulated and shall be equivalent to Ruskin model ARDD.
  11. Unless specifically noted otherwise or required by special constraints, all elbows on ductwork changing direction from vertical to horizontal shall be 1.5 times radius.

## 2.04 SPECIAL EXHAUST SYSTEMS

- A. Exhaust Stacks
1. High plume dilution type fans with integral air induction discharge nozzle shall not require additional exhaust stack. Refer to Section 23 39 00 (Fans and Accessories) for additional requirements of high plume dilution fans.
- B. Corrosive Exhaust Coated Ductwork System
1. General
    - a. Approved product shall be PermaShield Pipe (PSP) ductwork by Fab-Tech or as otherwise approved for use by the Architect and Owner.
    - b. Ducts shall be listed for use without the necessity for internal fire protection sprinklers or any devices relied on to cut off air flow in the event of fire by the following:
      - 1) Factory Mutual Research Standard 4922
    - c. All ducts shall be interiorly furnished with a fluoropolymer thermoplastic resin. The total interior coating thickness shall not exceed 16 mils (0.30 mm). Complete and uniform coating coverage is required.

- d. The product shall be manufactured with identical resins as tested, and according to the formulation on file with FMRC, and shall meet all physical requirements of SMACNA manual for Industrial Duct Construction Standards.
  - e. The manufacturer shall determine the suitability of the duct systems for specific corrosive environments.
  - f. If the process served by such duct system produces flammable residue or a combustible fume source exceeding  $1\text{ft}^2$  ( $0.09\text{ m}^2$ ) in area per inlet which can build up inside the duct, then internal sprinklers will be required.
  - g. ASTM E-84 Standard Test Method for Surface Burning Characteristics. Tested in flat sheet form at a 20 ga. (0.95 mm) thickness: Flame Spread 0, Smoke Density 20.
2. Ductwork
- a. Base Metal shall be a 316L Stainless Steel. Longitudinal seams shall be fusion welded. Traverse seams shall be continuous weld. All seams shall be smooth on the interior of duct.
  - b. Coating shall be PermaShield Fluoropolymer Barrier Coating and shall be applied per Factory Mutual Research Corporation's limitations and requirements.
  - c. Testing shall be performed at the factory over the entire coated surface inside and out (where applicable) and edges. The testing shall be performed with a DC spark tester used at 2500 volts.
  - d. Delivery, Storage, and Handling:
    - 1) Protection: Protection is factory applied to ends of ductwork to prevent end damage and prevent dirt and moisture from entering ducts and fittings.
    - 2) Delivery: Consignee must inspect shipment upon delivery and note any and all damages and discrepancies on Bill of Lading and notify manufacturer within 24 hours.
    - 3) Storage: Coated ductwork should not be stored in an area where it will have a chance to be damaged from traffic or debris. All coated ductwork should be stored on cardboard, Styrofoam or similar materials. Where possible, store inside and protect from dirt and debris. Where necessary to store outside, store above ground and enclose with water proof wrapping to protect from dirt and debris.
    - 4) Handling: If coating is scratched use appropriate protocol to "spark test" (refer to Installation and Assembly Guide, Field Modification section) and if spark is detected, contact manufacturer for repair instruction.
    - 5) Welding: Under no circumstances shall welding or a heat source greater than  $300^{\circ}\text{F}$  ( $150^{\circ}\text{C}$ ) be allowed on the stainless steel surface of the duct.
  - e. Duct installation and assembly shall be in accordance with the manufacturer's recommendations.
  - f. Gasket
    - 1) Ring gasket material shall be a form in place, fully expanded 100% PTFE joint sealant.
    - 2) Clamp gasket material shall be a form in place, fully expanded 100% PTFE tape or die cut gasket.

## 2.05 ACCESS DOORS

- A. Provide access doors and frames in all supply, exhaust and return ductwork as required, to permit access to:
  - 1. Automatic dampers
  - 2. In-box heating coils
  - 3. Fire dampers
  - 4. In-duct coils

5. All plenums
6. In-duct humidifiers
  - a. Provide sight doors
7. Other similar equipment
8. Fan Bearings enclosed in ducts.
9. Duct smoke Detectors
  - a. Provide sight doors
10. For cleaning and inspection purposes
11. Where indicated on the drawings

B. Door construction

1. Door size
  - a. Ductwork
    - 1) Minimum 20" x 16"
    - 2) In ducts smaller than 16" they shall be 20" x 2" less than duct width except:
      - a) Terminal Box heating coil door may be 12" x 6"
  - b. Plenums
    - 1) Shall be 20" x 56"
      - a) 18" x 45" door may be used only when 20" x 56" will not fit.
    - 2) Larger door shall be provided if required for equipment removal. Coordinate with equipment.
2. Doors shall match material type and gauge of the duct system in which they are installed.
3. Minimum gauge shall be 22.
4. Provide a neoprene gasketed around their entire perimeter.
5. Where sight doors are required, a wire reinforced safety glass shall be utilized.
6. Insulated or lined ductwork shall have insulated door
7. Insulated plenums shall have insulated door
8. Insulated doors shall be double wall.
9. Insulation between the metal panels shall be of the same thickness as the duct or panel adjacent to the access doors.
10. All access doors shall be hung on heavy hinges and shall be secured in the closed position by means of cast zinc clinching type cam latches
11. Hinged doors shall be similar to Greenheck model HAD-10.
12. Where space conditions preclude hinges, a minimum of (2) cams shall be utilized in low pressure ductwork and a minimum of (4) heavy window type latches shall be utilized in ductwork over 2" pressure class. In all cases where hinged doors are not utilized, a safety retainer chain shall be provided.
13. Cammed doors shall be equivalent to Greenheck model CAD-10.
14. All fire damper access doors in all positive pressure supply ductwork of +3" w.g. or greater construction:
  - a. Shall be of the pressure relief (negative pressure) spring loaded type. Design shall incorporate self-closing spring latch or be complete with secure retainer chain and "D" handle.
  - b. These doors shall be mounted downstream (after shutoff) of fire dampers, fire/smoke dampers or smoke dampers or similar automatic shutting devices.
  - c. These doors shall be of the automatic reset type and similar to Ruskin model ADHP-3.

2.06 FLEXIBLE CONNECTIONS (FANS)

- A. Provide flexible connections of 4" minimum fabric width
  1. Between ductwork and the inlets and outlets of all fans **except**:
    - a. Hazardous exhausts
    - b. Lab exhaust fans located indoors.

2. Equipment equipped with fans
  3. All ductwork that crosses building expansion joints
- B. The connections shall be placed as close to the equipment as practical except at fan suction connections and the clear gap at rest shall be not less than 3". At fan suction connections, locate flexible duct connection at least 3 duct diameters away from fan inlet connection.
- C. There shall be no tension of the fabric under static or dynamic loads
- D. All fabric for flexible duct connections to equipment shall be a minimum of 22 oz. glass fabric, double coated with neoprene, fire retardant, waterproof, airtight, and approved by UL, similar to Ventfabrics or Ventglass.
- E. Exterior flexible connection shall be insulated type similar to Duro Dyne.
- F. Flexible connections shall be fabricated from approved flameproofed fabric conforming to NFPA 90A. Asbestos shall not be acceptable.
- G. Flexible connections shall be installed further upstream from fan powered equipment (in the main duct size) to prevent obstruction of the fan inlet due to suction of the fabric into the airstream.
- H. Ductwork shall be increased in size where the flexible connections are located to prevent fully drawn in connections from blocking any duct area. Submit detail for review.

## 2.07 FLEXIBLE DUCTWORK

- A. General
1. Flexible duct runs must not exceed 5'-0" in length. Flexible duct shall not exceed a maximum of 1/2" sag per linear foot when installed horizontally.
  2. Flexible ductwork shall be supported at a maximum spacing of 2'-6", and as detailed on the drawings. Ductwork must not be compressed. Duct elbows must not exceed 45°.
- B. Flexible Duct (Rigid)
1. Flexible duct shall be similar to Flexmaster Triple Lock Buck Duct Flexible Air Duct. Flexible duct (insulated) shall be UL 181, Class 0 listed air duct and constructed in accordance with NFPA 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
  2. Triple Lock Buck Duct shall be made from a tape of dead soft aluminum sheet, spiral wound into a tube and spiral corrugated to provide strength and stability. The joint shall consist of a triple lock that is mechanically performed without the use of adhesives to make a durable airtight seam. A double lock is not acceptable.
  3. Insulated flex shall have a gray fire retardant polyethylene outer jacket with an 8 oz. density, 1 1/2" thick fiberglass insulation blanket, factory wrapped.
  4. The flexible duct shall be supported as required.
  5. Flexible ductwork shall be rated at 12" positive pressure. Duct from 3" to 16" shall have a negative pressure 12" and duct from 18" to 20" shall have a negative pressure of 8".
  6. All flexible duct shall be individually cartoned and labeled for delivery to the job site for maximum protection.
  7. Provide:
    - a. Where indicated in construction greater than +2" or less than -2".
    - b. Upstream of supply boxes.
  8. Flexible duct is not allowed on exhaust systems.

C. Flexible Duct (Fabric)

1. Flexible duct shall be similar to Flexmaster Type 2. Flexible duct (insulated) shall be UL 181, Class 1 listed air duct and constructed in accordance with NFPA 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
2. Duct fabric shall be of a heavy duty coated fiberglass cloth fabric. The fabric material shall be mechanically locked to the outside helix. (Use of adhesives to lock fabric in place is unacceptable.) The helix is constructed of a corrosive resistant galvanized steel, formed and mechanically locked to the duct fabric on the outside to prevent tearing of the flexible duct.
3. Insulated flex shall have a gray fire retardant polyethylene outer jacket with an 8 oz. density, 1 1/2" thick fiberglass insulation blanket, factory wrapped.
4. The flexible duct shall be supported as required to prevent sagging. Flexible duct with excessive sagging will not be approved.
5. Flexible ductwork shall be rated at 12" positive pressure and 10" negative pressure. Negative pressure for 14"R and 16"R shall be 5" and negative pressure for 18"R shall be 1".
6. All flexible ducts shall be individually cartoned and labeled for delivery to the job site for maximum protection.
7. Provide:
  - a. Where indicated in  $\pm 2$ " duct construction, except exhaust.
  - b. Downstream of supply boxes.
8. Flexible duct is not allowed on exhaust systems.

2.08 DAMPERS

A. General

1. The minimum damper requirements shall be as indicated in the following table:

| Damper Construction Table   |                         |                 |                               |                      |                |                       |
|---|-------------------------|-----------------|-------------------------------|----------------------|----------------|-----------------------|
| Type  | Approach Velocity (FPM) | Pressure Rating | Instantaneous Pressure Rating | UL555S Leakage Class | Blade Type     | Listing               |
| Fire dampers in ducts greater than +2" w.g. or less than -2" w.g. (FD)                          | 2,000                   | 4" w.g.         | 10" w.g.                      | N/A                  | OBD 3V         | UL555 Dynamic         |
| Other fire dampers (FD)   | 2,000                   | 4" w.g.         | 8" w.g.                       | N/A                  | Curtain or OBD | UL555 Dynamic         |
| Fire smoke dampers in ducts greater than +2" w.g. or less than -2" w.g. and at all shafts (FSD) | 3,000                   | 4" w.g.         | 14" w.g.                      | I                    | Air Foil       | UL555, UL555S Dynamic |
| Other fire smoke dampers (FSD or HFD)   | 2,000                   | 4" w.g.         | 8" w.g.                       | I                    | OBD 3V         | UL555, UL555S Dynamic |
| Smoke dampers (SD)  | 3,000                   | 4" w.g.         | 14" w.g.                      | I                    | Air Foil       | UL555S Dynamic        |
| Isolation dampers (at units)  | 4,500                   | 8" w.g.         | 20" w.g.                      | I                    | Air Foil       |                       |
| Automatic dampers (AD)  | 4,500                   | 6" w.g.         | 14" w.g.                      | I                    | Air Foil       | N/A                   |
| Balancing dampers in ducts wider than 48" and/or deeper than 12" (VD or as specified)           | 2,500                   | 4" w.g.         | N/A                           | N/A                  | OBD            | N/A                   |

| Damper Construction Table   |                         |                 |                               |                      |            |         |
|---|-------------------------|-----------------|-------------------------------|----------------------|------------|---------|
| Type  | Approach Velocity (FPM) | Pressure Rating | Instantaneous Pressure Rating | UL555S Leakage Class | Blade Type | Listing |
| Balancing damper in ducts less than 48" by 12" (VD or as specified) | 2,500                   | 2"              | N/A                           | N/A                  | OBD        | N/A     |

2. Dampers in stainless steel ducts shall be stainless steel.

B. Automatic Dampers

1. See Automatic Temperature Control Specification.

C. Fire Dampers, Ceiling Radiation Dampers, Smoke Dampers, and Combination Smoke/Fire Dampers

1. Fire dampers, smoke dampers and combination smoke/fire dampers shall be provided as shown on the drawings and wherever Architectural drawings indicate fire and/or smoke rated partitions. Devices shall be of the appropriate service for the partition class into which they are installed. Exact requirements and type of partition shall be coordinated with the Architect.
2. All dampers shall meet the requirements of NFPA 90A and further shall be tested, rated and labeled in accordance with UL 555 (6<sup>th</sup> Edition), UL555S (4<sup>th</sup> Edition) and UL555C (1<sup>st</sup> Edition).
3. All dampers shall be tested, rated and labeled as "Dynamic Rated" for closure against airflow in the following configuration:
  - a. Vertical mount (horizontal airflow):  
Ducted and unducted.
  - b. Horizontal mount (airflow up):  
Ducted and unducted.
  - c. Horizontal mount (airflow down):  
Ducted and unducted.

**Note:** Static rated dampers shall not be allowed.

4. Each damper shall be rated to close against maximum design airflow at its installed location, with 400 fpm and .5 in wg. safety factors and against 4" w.g. maximum pressure across the closed damper.
5. All dampers of all ratings and types shall be of the nominal 100% face area type, with blade package and all frame components out of the airstream. These dampers shall include the required oversize enclosures which shall be sealed by the damper manufacturer for the appropriate duct pressure class into which they are installed. All such dampers shall have appropriate rectangular, flat oval or round duct collars to facilitate connection of mating ductwork. The Contractor shall be responsible for any additional sealing of duct collars and connections required to maintain the duct seal class requirements but shall not jeopardize the UL breakaway connection when utilized.
6. The Contractor shall indicate the location and rating of all dampers on his shop drawings and shall provide access doors at each location of sufficient size and type to permit access to the damper components. A list of fire dampers shall be provided for review. The Contractor shall be solely responsible to coordinate all locations of duct access doors and dampers of all types.

7. Contractor shall include damper manufacturer's installation instructions as part of the damper submittal. These instructions shall describe the applicable requirements for damper sleeve thickness; retaining angles; sealing; duct-to-sleeve connections; preparation of wall, floor or ceiling openings; and all other requirements to provide an installation equivalent to that tested by the damper manufacturer during the UL 555, UL555S and UL555C qualification procedures. Contractor shall detail any proposed installations that deviate from these manufacturer's instructions and explain the needed deviations. All fire, smoke and ceiling radiation damper installations shall comply with the manufacturer's installation instructions. Any submitted deviations must be acceptable to the appropriate authority having jurisdiction.
8. Fire Dampers
  - a. Fire dampers shall be provided as shown on the drawings and wherever Architectural drawings indicate fire-rated partitions to the following schedule:

| Partition Assembly<br>Fire Rating | Penetration<br>Type        | Damper Rating                           |
|-----------------------------------|----------------------------|---|
| 1 Hour                            | Ducted and Sprinklered     | No damper; duct sleeved and packed only |
| 1 Hour                            | Ducted and Non-Sprinklered | 1.5 Hour                                |
| 1 Hour                            | Open (Transfer)            | 1.5 Hour                                |
| 1.5 to 2 Hours                    | Ducted or Open             | 1.5 Hour                                |
| 3 Hour                            | Ducted *                   | 3.0 Hour                                |
| 4 Hour                            | Ducted *                   | 3.0 Hour                                |

\*No open transfer will be permitted through these partitions.

- b. Fire damper sleeves shall be manufactured with a metal sleeve of appropriate length and thickness for the required damper installation as shown in the table below:
 

| <u>Maximum Duct I.D.</u> | <u>Sleeve Gauge (U.S.)</u> |
|--------------------------|----------------------------|
| Up to 84"                | 20 gauge                   |
| 85" & Up                 | 18 gauge                   |
    - c. Fusible link temperature rating for all fire dampers shall be 212°F or 50°F above the highest system temperature, whichever is greater.
    - d. Dampers in stainless steel ducts shall be stainless steel.
    - e. Dampers located in welded systems shall be rigidly connected with welded connections (not breakaway).
  9. Smoke Dampers and Combination Fire/Smoke Dampers
    - a. Smoke dampers and combination fire/smoke dampers shall be provided as shown on the drawings and wherever architectural drawings indicate smoke/fire rated partitions. Combination fire/smoke dampers shall be dynamically rated for 1.5 or 3 hours as determined by the Architect.
    - b. Smoke dampers and combination fire/smoke dampers and actuators shall meet the requirements of NFPA 92A and NFPA 92B and further shall be tested, rated and labeled as a "Leakage Rated Damper for Use in Smoke Control Systems" in accordance with the 4th edition of UL 555S. All smoke dampers shall be of low leakage design qualified to UL 555S Leakage Class I (maximum leakage of 4 cfm/sq.ft. at 1" w.g. and 8 cfm/sq.ft. at 4" w.g.) and shall have a UL 555S elevated temperature rating of 350°F.
      - 1) Each smoke damper/actuator combination shall be UL 555S rated to operate at maximum design airflow at its installed location with 400 fpm and .5 in wg. safety factors.



- c. Each smoke damper and combination fire/smoke damper shall be supplied with an appropriate damper actuator installed by the damper manufacturer at the time of damper fabrication. Combination fire/smoke dampers shall be manufactured with a metal sleeve of appropriate length and thickness for the required damper installation, and the damper actuator shall be installed on the sleeve exterior. Smoke dampers may be installed in ductwork up to 24" from wall with no openings between the wall and the smoke damper.
    - 1) Damper actuators shall be electric type for 120 volt operation.
    - 2) Power wiring, including interlocking to smoke detectors and fire alarm system, and panels to affect the sequence of operation shall be by the Electrical Contractor.
    - 3) Dampers shall be fail closed as follows:
      - a) Power to Damper: Open
      - b) No Power to Damper: Closed
  - d. Damper frame shall be galvanized steel formed into a structural hat channel shape with reinforced corners. The smoke and combination fire/smoke damper blades shall be airfoil type with Class 1 leakage rating. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Blade edge seals shall be silicone rubber designed to withstand 450°F (232°C) and jamb seals shall be stainless steel flexible metal compression type.
  - e. Each damper shall be equipped with a remote open or closed position indication switch. The switch shall be over the shaft type using two independent rotary cams and adjustable switch points indicating open and closed positions. Switch can be factory or field applied to manufacturer's damper.
    - 1) These switches shall be furnished by the damper manufacturer and wired by the Electrical Contractor, in a location approved by the Architect.
    - 2) Spare contacts shall be provided for additional remote (fire panel) operation.
  - f. Each combination fire/smoke damper shall also be equipped with a temperature limited re-openable feature equivalent to Greenheck model TOR providing the following operational sequence:
    - 1) Temperature at damper fusible device reaches 165°F or 50°F above highest system temperature, whichever is greatest, and primary heat sensing device closes damper. Remote or local override command panel can then re-open damper.
    - 2) If temperature at damper fusible device reaches 250°F, secondary heat sensing device will close the damper. Override and re-opening above this secondary temperature is not permitted. Both primary and secondary heat responsive devices shall incorporate a manual reset feature allowing restoration of normal operation after fire emergency has been cleared.
  - g. If utilizing system operation for smoke control purposes during the early phase of a fire emergency, each combination fire/smoke damper shall be equipped with a 286°F primary fusible device and 350°F minimum rated damper actuator. .
  - h. Dampers in stainless steel ducts shall be stainless steel.
  - i. Dampers located in welded systems shall be rigidly connected with welded connections (not breakaway).
10. Smoke Isolation Dampers at Air Handling Units
- a. Provide smoke isolation dampers at air handling units as shown on drawings. Smoke dampers shall comply with NFPA 90A, UL 555S and the aforementioned requirements. Dampers shall be electrically operated, with a minimum of (1) actuator for every 16 sq.ft. of damper or portion thereof.
    - 1) Power to Damper: Open
    - 2) No Power to Damper: Closed

- b. The ATC Contractor shall provide all PE and EP switches, relays, etc., for ready wiring to the following schedule:

| Device                      | Furnished By | Installed By | Actuator By         | Actuator Type | End Switches        | Control Air | Control Wires | Power | UL Assembly |
|-----------------------------|--------------|--------------|---------------------|---------------|---------------------|-------------|---------------|-------|-------------|
| Automatic Damper (AD)       | ATC          | HVAC         | ATC                 | Electric      | ATC                 | N/A         | ATC           | ATC   | No          |
| Fire Smoke Damper (FSD)     | HVAC         | HVAC         | Damper Manufacturer | Electric      | Damper Manufacturer | N/A         | Elec          | Elec  | Yes         |
| Smoke Damper (SD)           | HVAC         | HVAC         | Damper Manufacturer | Electric      | Damper Manufacturer | N/A         | Elec          | Elec  | Yes         |
| Smoke Isolation Damper (SD) | HVAC         | HVAC         | Damper Manufacturer | Electric      | Damper Manufacturer | N/A         | ATC           | Elec  | Yes         |
| Fire Damper (FD)            | HVAC         | HVAC         | N/A                 | N/A           | N/A                 | N/A         | N/A           | N/A   | Yes         |

D. Volume Dampers

- Volume dampers shall be provided at each branch duct and as indicated on drawings for supply air duct systems, return air duct systems and exhaust air duct systems.
- Comply with SMACNA Figure 2-12 with continuous rod and closed end bearings regardless of pressure class.
- Use 3/8" continuous square rod and 18 gauge galvanized stiffened blade for damper blade sizes 18" wide by 18" high and smaller, or 12" diameter and smaller.
- Use 1/2" continuous square rod and 16 gauge galvanized stiffened blade for damper blade sizes 19" to 48" wide by 10" high. Maximum blade size is 48" by 10" high. Maximum diameter is 16".
- Maximum of two blades without a frame: Over two blades, use a manufactured 16 gauge galvanized, stiffened, opposed blade damper in a 14 gauge galvanized steel frame. All hardware shall be galvanized except use brass trunions and bronze olite bearing.
- Quadrant shall be Ruskin, Prefco or equal.
- Cut slot in end of damper rod (Quadrant End) to indicate blade position.
- Provide galvanized sheet metal "hat section" on ducts with exterior insulation so that quadrant will be exposed. Provide tight sealing nylon brushing at duct opening for damper shaft under hat section.
- Each square rod shall be installed vertical or horizontal so that quadrant will be accessible for adjusting.
- Provide minimum 24" x 24" access door for each volume damper that is not accessible, in a location as approved by the Architect.
- Provide cable operated damper regulator (Young Model 896C or equal) for adjustment of volume dampers above inaccessible GWB ceilings. Damper operator shall extend to remote regulator installed with 7/8" diameter cold rolled steel cover and is zinc plated for painting. Locate remote regulator, within distance prescribed by the manufacturer, in a location approved by the Architect.

E. Backdraft Dampers

- Backdraft dampers shall be counterbalanced and designed for installation in horizontal (upflow) or vertical position.
- Damper blades and frames shall be constructed of extruded aluminum with aluminum pivots, nylon bearings and foam gasket.
- Damper shall be capable of opening at less than 0.05" w.g.
- Damper leakage shall not exceed 32 cfm/s.f. with 1" pressure differential, based on testing of 24" x 24" nominal damper.
- Provide counterbalance assemblies, as required, for field adjustment to necessary operation pressure.

### PART 3 - EXECUTION

#### 3.01 SHEET METAL INSTALLATION

- A. All ductwork shall be installed to true alignment, generally parallel or perpendicular to adjacent building walls, floors and ceilings, so as to present a neat and workmanlike appearance. All fabricated, stored and installed ductwork shall be protected with removable caps, plastic or other means to prevent dirt, water and debris from entering duct system. The Sheet Metal Contractor shall be responsible for maintaining a clean duct system and shall clean and/or replace any ductwork identified by the Owner or Architect as being deficient or dirty. The Sheet Metal Contractor shall be responsible for all costs associated with the temporary protection cleaning and/or replacement of ductwork. All fabrication labels shall be applied to the exterior of the duct. The Sheet Metal Contractor shall be responsible for the removal of all internal labels if such labels were incorrectly applied.
- B. Care shall be paid to the exact locations of all sheet metal work with respect to equipment, ducts, conduits, piping, slabs, beams, columns, ceiling suspension systems, lighting fixtures and electrical, plumbing and fire protection systems in the building. Close coordination and cooperation shall be exercised with other Trades in locating the piping and equipment in the best interests of the Owner. The drawings and specifications covering other work to be done in the building shall be carefully studied and arrangements shall be made to avoid conflict.
- C. The drawings shall be followed where they are definite and provided such procedures do not cause objectionable conditions for equipment provided installed under this Contract. The drawings are intended to indicate the sizes of ductwork and if certain sizes are omitted or unclear, obtain additional information before proceeding.
- D. Locate and size all openings for ductwork in the building construction. Provide all sleeves as hereinbefore specified.
- E. Provide access doors in ductwork at the following locations:
1. Both sides of all coils
  2. Fire dampers
  3. Smoke dampers
  4. Fire/Smoke dampers
  5. Both sides of automatic dampers
  6. Humidifiers
  7. Both sides of filters
  8. At all exhaust and intake plenums, doors shall allow full body access in all plenums over 4'-0" tall.
  9. Otherwise indicated or specified
- F. Provide labels with a minimum of 1" high red letters on white background. Each access door shall be labeled as follows (or worded as required by Code):
1. Fire Damper
  2. Fire/Smoke Damper
  3. Smoke Damper
  4. Automatic Damper
  5. Humidifier
  6. Filter Access
  7. Coil Access

- G. The installation of special items of equipment in the duct systems, including automatic dampers, thermostats, thermometers, duct airflow measuring devices and other related controls, shall be done by this Contractor under the direct supervision of the manufacturer of such controls.
- H. All elbows, tees and branch takeoffs in round ductwork shall be made of the same materials as the ductwork.
- I. Duct connections to equipment shall be in no case smaller than the equipment openings.
- J. All openings for pitot tube traverses shall be fitted with neat removable plugs or caps. As a minimum, such openings shall be provided at every fan inlet and at such other points as may be required for airflow measuring and balancing. Coordinate the location of plugs and caps with the Balancing Contractor.
- K. All internally lined duct sections and joints shall be closely inspected by the contractor before and after each piece is erected. Loose edges, open joints, damaged areas and other defects shall be sealed securely so as to insulate all metal surfaces and so as to endure without falling in the presence of moving air. All liner applications shall comply with SMACNA "Duct Liner Application Standard".
- L. Provide other miscellaneous sheet metal work shown on the drawings including blanking off portions of louvers not required for the specific usage and diffusion plates or mixing air scoops to allow for air mixing where job conditions require the provision of same. All above work shall be provided as part of this Contract at no extra cost to the Owner.
- M. Where applicable and as approved by the Architect, all exposed ductwork shall be installed in a workmanlike manner to result in a neat appearance with no visible penetrations, screws, or other sheet metal imperfections.
- N. Install all UL classified devices in accordance with their UL approved installation sheets.
- O. Counterflashing of duct penetrations through roof shall be provided under this Contract.

### 3.02 DUCT HANGERS AND SUPPORTS

- A. Provide suitable angle iron/strap hangers and supports inside the mechanical shafts, mechanical rooms and in ceilings of the buildings, and on the roof(s) as shown on the drawings (Architectural/HVAC). This work shall be performed as required by job conditions and as instructed by the Architect in the field to support all air distribution ductwork and devices in both horizontal and vertical planes.
- B. When hanging and supporting the ductwork, the following shall be complied with:
  - 1. Except as otherwise noted, ductwork up to 42" in greatest dimension shall be hung by using sheet metal bands secured as a minimum at (2) locations to the vertical sides of the ductwork and at (1) location under the duct. All support systems shall be compatible with the building structure and roofing system as approved by the Architect.
  - 2. Where ductwork major axis dimension is larger than 42", ductwork shall be hung by using rods of not less than 3/8" soft steel secured to angle iron trapeze support frame around ductwork with threaded nuts for securement and adjustment. All rods used on ductwork exposed in finished spaces shall be plain smooth rods threaded only at the ends.

3. Ductwork shall be securely attached to the building construction. The hanger design and spacing shall be governed by the major duct dimension and shall be in accordance with SMACNA Duct Manual, except as modified hereinbefore. Vertical ductwork shall be supported at each floor level in an approved manner using angles or channels attached to the ducts. The installation, when complete and under operating conditions, shall be free from chatter or vibration. If necessary to achieve this, additional supports and/or bracing shall be furnished without extra cost to the Owner. Supports and bars and similar items shall be primed and painted structural steel. Touch up with aluminum paint any surfaces where galvanizing is destroyed on indoor ductwork, zinc primer on exposed ductwork with a final coat of aluminum paint. Provide vibration isolation hangers where specified under Vibration Isolation Section of these specifications.
4. The Sheet Metal Contractor shall provide all supplemental steel required to support the ductwork in shafts, mechanical rooms or on the floor where structural steel is not properly positioned. Beam clamps shall be double sided.
5. The maximum hanger spacing shall be 10'-0" on centers and additionally on each side of an elbow or change-in-direction fitting.
6. In addition to the above, provide supports on each side of any duct mounted device, fans, coils, flow measuring stations, framed dampers, etc., to permit removal of the device without disconnecting adjacent duct sections.
7. Provide angle sway bracing to the structure wherever lateral loads would be imposed on the ductwork, including but not limited to:
  - a. Elbows downstream of fan discharges.
  - b. Ductwork exposed to the weather subject to wind loads.
8. Ductwork mounted on the roof or otherwise exposed to the elements shall be supported with frames constructed of steel angles and channels regardless of duct size.
  - a. Coordinate all roof supports with General Contractor.
  - b. Provide diagonal cross bracing between supports as required to sustain maximum area wind loads as dictated by the Architect.

### 3.03 SHEETMETAL TESTING

#### A. General

1. All ductwork that is required to be tested shall be tested on regular intervals as the job proceeds and shall be completed prior to enclosure in shafts, above ceilings or behind walls.
2. The Sheet Metal Contractor shall keep an up-to-date log of the ductwork tested for review by the Architect. The Sheet Metal Contractor shall notify all other Contractors when the testing is completed and accepted to permit enclosure of ducts.
3. The Sheet Metal Contractor shall furnish and install all blank off plates, blind flanges, safing, etc., necessary to isolate each section of duct being tested for leakage.
4. The Sheet Metal Contractor shall submit for review all proposed testing procedures, sample report, and equipment to the Engineer prior to proceeding. Additionally, the Sheet Metal Contractor shall notify the Engineer when testing is to occur so that the test can be witnessed at the Engineer's option.
5. All test equipment shall be calibrated per ANSI Standards prior to testing. Certified test reports shall be submitted to the Architect prior to commencement of the testing.
6. Testing Procedure
  - a. The testing procedure shall be in accordance with SMACNA "HVAC Air Duct Leakage Test Manual".
  - b. The test pressure shall be the specified construction pressure of the duct system.

7. Scope of Testing
  - a. All ductwork (regardless of pressure class) that will be in inaccessible areas including, but not limited to, all ducts within shafts, above hard ceilings, and those that will be made inaccessible by the work of other Trades. (This shall include  $\pm 2$ " w.g. construction.)
  - b. All ductwork constructed to greater than +2" w.g. or less than -2" w.g.
  - c. All other sheet metal in duct systems constructed to  $\pm 2$ " w.g. shall be tested under normal fan pressure and shall not leak sufficiently to cause audible leaks or blowing detectable by hand. **If, in the opinion of the Architect, the ductwork does not appear to be constructed and/or sealed to the approved shop standards, the Architect may request any or all of this ductwork to be tested at the specified construction pressure.**
  - d. Allowable Leakage
    - 1) The total allowable leakage shall be less than specified leakage class with no audible leaks.
    - 2) If no leakage class is listed elsewhere, the system shall meet leakage Class 4.

### 3.04 DUCT CLEANING

- A. Clean dust and debris from interior and exterior of all ducts using wet rags and vacuums.
- B. Cover open ends of ductwork when installation does not proceed for more than one day. This requirement shall apply to each individual run of duct, such that no duct section shall remain open or unconnected for more than 8 hours.

**END OF SECTION 23 31 00**

## **SECTION 233319 – SOUND ATTENUATORS**

### **PART 1 - GENERAL**

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

#### 1.02 WORK INCLUDED

- A. Duct Sound attenuators.

#### 1.03 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

#### 1.04 REFERENCES

- A. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- B. UL 181 - Factory-Made Air Ducts and Connectors.
- C. NFPA 70 - Electric Duct Heaters.
- D. ASTM A 653/A653M Steel Sheet, Zinc Coated Galvanized.
- E. ASTM C 553 Mineral fiber Blanket and felt.
- F. ASTM C 612 Mineral fiber Block and Board Thermal insulation.
- G. ASTM E 84 Surface Burning Characteristics of Building materials.
- H. NFPA 255 Surface Burning Characteristics of Building materials.
- I. UL 723 Surface Burning Characteristics of Building materials.
- J. ASTM E-477-99

#### 1.05 SUBMITTALS

- A. See Section 230500 and General Conditions for additional requirements.
- B. Submit shop drawings and product data sheets indicating configuration, general assembly, and materials used in fabrication.
- C. Submit product performance data indicating design air flow, minimum static pressure drop at operating condition.

- D. Submit sound power and noise criteria (NC) values for radiated and discharge paths.
- E. Submit installation, operation and maintenance documentation.
- F. The manufacturer shall supply certified test data for each scheduled silencer. The data shall include dynamic insertion loss, generated noise and pressure drop for forward or reverse flow, matching the project's air distribution system requirement. All ratings shall be conducted in the same facility and shall utilize the same silencer.
- G. Test facilities and test reports shall be open to inspection upon request from the Engineer. Silencer performance must have been substantiated by laboratory testing according to ASTM E-477-99 and so certified when submitted for approval.
- H. Acoustic laboratory must be NVLAP accredited for the ASTM E-477-99 test standard. A copy of the accreditation certificate shall be included with the submittals. **Data from non-NVLAP accredited test facilities will not be accepted.**

#### 1.06 QUALIFICATIONS

- A. Manufacturer: The company manufacturing the products specified in this section shall have a minimum of ten years experience producing products of this type.

#### 1.07 WARRANTY

- A. Provide manufacturer's parts warranty for one year from unit start-up.

### PART 2 - PRODUCTS

#### 2.01 GENERAL

- A. Acceptable manufacturers contingent on compliance with the specifications:
  - 1. Vibro Acoustics
  - 2. VAW Systems
  - 3. Dynasonics
  - 4. United McGill
  - 5. Kinetics Noise Control
  - 6. Commercial Acoustics
- B. Silencers in aluminum systems shall be aluminum with all casing gauges adjusted accordingly.
- C. Silencers in stainless steel systems shall be stainless steel.
- D. Silencer in galvanized systems shall be galvanized steel.
- E. Silencer in welded systems shall be continuously welded. See sheet metal section.
- F. All gauges are based on steel. If aluminum is required equivalent strength aluminum gauges shall be used.



## 2.02 CIRCULAR SILENCERS

- A. All circular silencers shall be constructed with a casing of a minimum gauge noted below and minimum 22 gauge galvanized perforated internal liner. All casing seams and joints shall be lockformed and sealed or stitch welded and sealed except welded system shall be continuously welded.

| <u>Casing Diameter</u> | <u>Casing Gauge</u> |
|------------------------|---------------------|
| a. Less than 30"       | 20                  |
| b. 30" to 54"          | 18                  |
| c. Over 54"            | 16                  |

- B. All packless circular silencers shall be constructed with a casing of a minimum gauge noted below and minimum 26 gauge perforated internal liner. All casing seams and joints shall be lockformed and sealed except welded systems shall be continuously welded.

| <u>Connection Diameter</u> | <u>Casing Gauge</u> |
|----------------------------|---------------------|
| a. Less than 18"           | 22                  |
| b. 18" to 30"              | 20                  |
| c. 30" to 54"              | 18                  |
| d. Over 54"                | 16                  |

- C. All welded silencers shall be a minimum of 16 gauge.

## 2.03 RECTANGULAR SILENCERS

- A. All rectangular silencers shall be constructed with a casing of a minimum gauge noted below and minimum 22 gauge perforated internal liner. All casing seams and joints shall be lockformed and sealed except welded systems shall be continuously welded.

| <u>Connection Dimension</u> | <u>Casing Gauge</u>  |
|-----------------------------|----------------------|
| a. Less than 48"            | 22                   |
| b. Over 54"                 | Provide Calculations |

- B. All welded silencers shall be a minimum of 16 gauge.

## 2.04 ELBOW SILENCERS

- A. All elbow silencers shall be constructed with a minimum 18 gauge outer casing and minimum 22 gauge perforated internal liner. All acoustical splitters shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters are required as necessary to achieve the scheduled insertion loss. All elbow silencers with a turning cross-section dimension greater than 48" shall have at least two half splitters and one full splitter.

- B. All welded silencers shall be a minimum of 16 gauge.

## 2.05 TRANSITIONAL SILENCERS

- A. All transitional rectangular silencers shall be constructed with a minimum of 22 gauge outer casing and minimum 22 gauge perforated internal liner. Transitioning shall occur internal to the silencer such that the height of the gap or air passage is uniformly changing with the length of the splitters.

- B. All welded silencers shall be a minimum of 16 gauge.

## 2.06 ACOUSTIC MEDIA

- A. Dissipative and Film Lined silencers:
  - 1. Media shall be of acoustic quality, shot-free glass fiber insulation with long, resilient fibers bonded with a thermosetting resin. Glass fiber density and compression shall be as required to insure conformance with laboratory test data. Glass fiber shall be packed with a minimum of 15% compression during silencer assembly. Media shall be bacteria and fungus resistant, resilient such that it will not crumble or break, and conforming to irregular surfaces. Media shall not cause or accelerate corrosion of aluminum or steel. Mineral wool will not be permitted as a substitute for glass fiber.
- B. Packless (No-Media silencers):
  - 1. All No-Media silencers shall not contain absorptive media of any kind. Attenuation shall be achieved with controlled impedance membranes and broadly tuned resonators.

## 2.07 MEDIA PROTECTION

- A. Dissipative silencers:
  - 1. Where indicated on the silencer schedule, media shall be encapsulated in glass fiber cloth to help prevent shedding, erosion and impregnation of the glass fiber. Axial Cone silencers shall have a glass fiber cloth liner.
- B. Film Lined silencers:
  - 1. The acoustic media shall be completely wrapped with Tedlar film to help prevent shedding, erosion and impregnation of the glass fiber.
  - 2. The wrapped acoustic media shall be separated from the perforated metal by a factory installed ½" thick acoustically transparent spacer.
    - a. The spacer shall be flame retardant and erosion resistant.
    - b. A mesh, screen or corrugated perforated liner will not be acceptable as a substitute for the specified spacer.

## 2.08 COMBUSTION RATINGS

- A. Dissipative silencers:
  - 1. Silencer materials, including glass fiber shall have maximum combustion ratings as noted below when tested in accordance with ASTM E84, NFPA 255 or UL 723.
    - a. Flamespread Classification: 15
    - b. Smoke Development Rating: 5

## 2.09 FILM LINED SILENCERS

- A. Silencer materials, including glass fiber, Tedlar film and acoustical spacer shall have maximum combustion ratings as noted below when tested in accordance with ASTM E84, NFPA 255 or UL 723.
  - 1. Flamespread Classification: 20
  - 2. Smoke Development Rating: 45

## 2.10 HTL CASINGS(HIGH TRANSMISSION LOSS)

- A. Where indicated on the silencer schedule, silencers shall have high transmission loss (HTL) walls externally applied and completely sealed to the silencer casing by the silencer manufacturer to assure quality controlled transmission loss. The HTL walls shall consist of media, airspace, mass and outer protective metal skin, as required, to obtain the specified room noise criteria. Standard acoustical panels will not be accepted as HTL walls.

If requested by the Engineer, breakout noise calculations for each air handling and fan system shall be provided with the silencer submittal to insure compliance with the room noise criteria. Breakout noise calculations shall be based on the sound power levels of the specified equipment.

### **PART 3 - EXECUTION**

#### **3.01 CONSTRUCTION**

- A. Silencers shall be constructed in accordance with ASHRAE and SMACNA standards for the pressure and velocity classification specified for the air distribution system in which it is installed. Material gauges noted in "Section B Materials", are minimums.
  - 1. Material gauges shall be increased as required for the system pressure and velocity classification.
  - 2. The silencers shall not fail structurally when subjected to a differential air pressure of 12 inches water gauge.
- B. Casings shall be lockformed and sealed, except as noted in Section B Materials, to provide leakage-resistant construction. Airtight construction shall be achieved by use of a duct-sealing compound supplied and installed by the contractor at the jobsite.
- C. All perforated metal shall be adequately stiffened to insure flatness and form. All spot welds shall be painted.

### **PART 4 - SCHEDULES**

#### **4.01 SEE DRAWINGS FOR SCHEDULES.**

#### **4.02 ACOUSTIC PERFORMANCE**

- A. Silencer dynamic insertion loss shall not be less than that listed in the silencer schedule.
- B. Silencer generated noise shall not be greater than that listed in the silencer schedule.
- C. Acoustic performance shall include dynamic insertion loss and generated noise for forward flow (air and noise in same direction) or reverse flow (air and noise in opposite direction) in accordance with the project's air distribution system requirements.
- D. All silencer ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer in accordance with the ASTM E-477-99 test standard. The test set-up, procedure and facility shall eliminate all effects due to flanking, directivity, end reflection, standing waves and reverberation room absorption.

#### **4.03 AERODYNAMIC PERFORMANCE**

- A. Silencer pressure drops shall not exceed those listed in the silencer schedule. Silencer pressure drop measurements shall be made in accordance with the ASTM E-477-99 test standard. Tests shall be conducted and reported on the identical units for which acoustical data is presented.

**END OF SECTION 23 33 19**

## SECTION 233600 – AIR TERMINAL BOXES

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

#### 1.02 WORK INCLUDED

- A. Products specified in this section include:
  - 1. Supply/return/exhaust air terminal boxes.
  - 2. Integral heating coils:
    - a. Hot water.
  - 3. Sound attenuator:
    - a. Integral.
    - b. For external sound attenuator, refer to Section 23 33 19.

#### 1.03 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

#### 1.04 REFERENCES

- A. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- B. UL 181 - Factory-Made Air Ducts and Connectors.
- C. NFPA 70 - Electric Duct Heaters.
- D. UL 1995, Heating and Cooling Equipment.
- E. CUL C22.2 No. 236, Heating and Cooling Equipment.
- F. ARI 880 - Air-Conditioning and Refrigeration Institute Standard Rating Conditions for Air Terminals
- G. ASTM A 653/A653M (Steel Sheet, Zinc Coated Galvanized).
- H. A-A-1419 or F-F-310 Federal specification (filter element, Air conditioning, Viscous-impingement or Dry type, replaceable), Tested per UL 900.

#### 1.05 SUBMITTALS

- A. See Section 230500 and General Conditions for additional requirements.
- B. Submit shop drawings and product data sheets indicating configuration, general assembly, and materials used in fabrication.

- C. Submit product performance data indicating design air flow, minimum static pressure drop, fan operating condition.
- D. Submit sound power and noise criteria (NC) values for radiated and discharge paths.
- E. Submit installation, operation and maintenance documentation.

1.06 QUALIFICATIONS

- A. Manufacturer: The company manufacturing the products specified in this section shall have a minimum of ten years experience producing products of this type.

1.07 SYSTEM RESPONSIBILITY

- A. The Contractor shall be responsible for any and all costs associated with any and all changes resulting from the use of a supplier other than the listed acceptable manufacturers.

1.08 WARRANTY

- A. Provide manufacturer's parts warranty for one year from unit start-up.

**PART 2 - PRODUCTS**

2.01 GENERAL

- A. Acceptable manufacturers contingent on compliance with the specifications:
  - 1. Enviro-Tec
  - 2. Anemostat
  - 3. Metal Industries
  - 4. Krueger
  - 5. Nailor
  - 6. Price
- B. Provide variable volume (VV), constant volume (CV) and variable/constant volume (VCV) supply and/or return/exhaust type air terminals, with operating characteristics and other requirements so as to comply with schedules and details on the drawings and as hereinafter specified. The physical sizes of units shall not be larger than the scheduled units.
- C. Manufacturer shall participate in the ARI Certification program. Unit performance data shall be rated in accordance with ARI Standard 880. The manufacturer shall display the ARI Symbol on all units.
- D. Terminal units shall be UL listed as an entire assembly.
- E. All terminals shall be "Hospital Grade" and shall be equipped with a foil reinforced faced sheet covering of the acoustical/thermal lining. Additionally, for cleaning purposes, the terminals shall have integral gasketed access doors securely attached to the box upstream of the heating coil. The HVAC Contractor shall provide a duct mounted access door immediately downstream of the coil to allow for cleaning.
  - 1. INSULATION - Foil Faced - The interior surface of unit casing is acoustically and thermally lined with a minimum of 1/2 inch, 2.0 lb./cu. ft. density glass fiber with foil facing. The insulation R-Value shall be a minimum of 2.2.

The interior foil liner shall isolate the fiberglass insulation from the airstream and allow for cleaning of the terminal unit interior surfaces. Insulation shall meet NFPA-90A, UL 181 and bacteriological standard ASTM C 665.

- F. Unit performance shall be determined in strict accordance with ARI 880 (latest Edition) in an ARI certified laboratory. Acoustical data presented shall be for true reverberant room sound power in bands 2 thru 7. Any NC calculation application effects shall be clearly stated.
- G. Identify each terminal unit with clearly marked identification label and airflow indicator. Label shall include unit nominal air flow, maximum factory-set air flow, minimum factory-set air flow, and coil type.
- H. All boxes with heating coils shall be provided with an access door for inspection and cleaning of coil.

## 2.02 SINGLE-DUCT TERMINAL UNITS

- A. Provide air terminal units (boxes) of the single duct type, with integral hot water heating coils and integral or external sound attenuators, as scheduled and shown on the drawings. Units shall be similar to Enviro-Tec Model SDR -SA-WC or Model SSDII -SA-WC
- B. Terminal box casings shall be constructed of a minimum 22 gauge sheet metal casing and insulation as specified herein and a minimum 20 gauge for damper assembly construction.
- C. Terminal boxes shall be mechanically assembled and sealed for an airtight casing allowing a maximum air leakage of 0.5% at 3" w.g. Interior walls of the terminal casing shall be lined with 1/2" minimum dual density fiberglass insulation with 4 lbs./cu.ft. skin outer layer, rated for a maximum air velocity of 4500 fpm. Insulation and/or liner must meet all requirements of UL 723, ASTM C665 Bacteriological Standards, UL 723 Flamespread, ASTM 84 Flamespread, and NFPA 90A.
  - 1. Raw edges exposed to the airstream shall be secured with a metal edging for isolation. All terminals shall have the insulation faced with an internal liner foil reinforced Kraft facing (FRK), "Hospital Grade". All exposed foil lining edges must be wrapped, tucked and secured with metal brackets.
- D. As indicated on the drawings, supply air terminal boxes shall have sound attenuators at the discharge of supply air terminal boxes, between the terminal box damper and the air diffusers/registers.
- E. As indicated on the drawings, return air terminal boxes shall have sound attenuator at the inlet of return air terminal box, between the terminal damper and the return registers/grilles.
- F. Valve assembly shall be manufactured of a minimum 22 gauge air valve body to handle high pressure and a minimum 16 gauge composite damper blade, with key attached to a solid shaft. The shaft shall have a position indicator marked on the end to verify damper position. Two (2) galvanized damper blades shall sandwich closed cell foam gasket material to ensure minimum valve leakage. Damper leakage shall not exceed 2% of unit maximum rated capacity with inlet pressure up to 6" w.g. Damper shall pivot in nylon self-lubricating bearings and shall remain unaffected by temperature and humidity. The valve assembly shall have built-in maximum heavy gauge mechanical stops to prevent over-stroking of the damper.

G. Primary Air Pressure Sensor

1. The primary air valve shall include a differential pressure type sensor upstream of the damper blade. The sensor shall traverse the inlet collar (for total pressure) along (2) axis. A minimum of (12) sensing points shall be utilized. Each sensing point shall be centered within equal concentric cross-sectional areas for accuracy. The sensor shall be designed to average the pressure signals by utilizing a center averaging pressure chamber. Each of the pressure sensing points shall be connected to this chamber. The average signal of these pressures shall pass to the control device signal through a single port located on the center averaging chamber. Brass balancing taps and airflow calibration charts shall be provided for field measurements. The sensor shall be designed to provide an amplified differential pressure signal a minimum 2.5 times the equivalent velocity pressure signal for the same capacity as measured with a conventional pitot tube. Documentation shall be submitted which substantiates this requirement.

H. All constant and variable/constant volume supply terminals shall be equipped with hot water heating coils.

1. Coils shall be furnished by the terminal manufacturer as a complete assembly, with capacities and other characteristics as scheduled on the drawings.
2. Coils shall be enclosed in a sheet metal casing to match the size of the terminal.
3. Coils shall be connected to the terminal with slip and drive connections to allow for coil removal.
4. Terminals with water coils shall have access doors upstream of the coil for cleaning access. Coils shall have left- or right-hand connections to suit job conditions, and shall be 2-row to meet heating requirements.
5. Coils shall have aluminum plate fins (maximum of 10 fpi), and shall be tested with 400 psig hydrostatic pressure (underwater). All coils shall be performance certified in accordance with ARI 410 (latest Edition).

2.03 SINGLE DUCT RETURN OR EXHAUST BOX

A. Similar to single duct terminal units except.

1. Boxes shall be provided with a bellmouth at the inlet of the VAV sensing neck to minimize pressure drop.
2. Designed with the sound attenuator on the inlet side.

2.04 LARGE VOLUME CUSTOM SUPPLY/RETURN AIR TERMINAL BOXES

A. General

1. Provide custom built single duct variable volume control pressure independent assemblies of the size and capacities shown on the plans as manufactured by Greenheck IAQ-42 or equal.
2. All sound data shall be compiled in an independent ADC certified laboratory and in accordance with the latest version of ARI 880 and ASHRAE 130. All units shall be AR certified and bear the ARI certification label.

B. Construction

1. They shall be constructed of minimum 22 gauge minimum galvanized steel casing. The damper assemblies of 16 gauge galvanized steel shall be multiple opposed blade construction arranged to close at 45° from full open to minimize air turbulence and provide near linear operation. The casing shall have a leakage rate of less than 1% downstream of the damper at 1" pressure. The high side casing leakage shall not exceed 2% at 3" inlet pressure.

2. Assemblies shall be pressure independent and shall be able to be rest to any airflow between zero and the maximum cataloged cfm. Devices using cfm limiters will not be accepted. The differential static pressure of the basic assembly shall not exceed 0.10 inches water gauge for all sized with maximum inlet velocities of 2000 fpm or less.
3. The damper shafts shall operate in corrosion free Celcon bearings. The damper shall be fitted with flexible seals for tight closure and minimize sound generation. The damper leakage shall not exceed 2% of the nominal catalog rating at 3" inlet static pressure as rated by ARI 880 and ASHRAE 130.
4. The unit inlet shall be equipped with an Ebtron thermal dispersion technology airflow sensor using two thermistors per sensing point. The airflow sensor shall consist of one or two sensor probe and a microprocessor based transmitter. Each sensing point shall independently measure airflow and temperature prior to averaging. The transmitter shall be capable of processing 2 independent sensing points per location. Analog output shall be 0-10Vdc or 4-20mA signal. Individual sensor accuracy shall be at least 2% of Reading over the sensor probe operating range. The installed total accuracy for airflow shall be better than 5% of Reading throughout the operating ranges.
5. All constant volume supply and variable volume supply terminal units shall be provided with 3/4" dual density fiberglass insulation and an internal metal liner. All constant and variable volume return terminals shall be provided with no internal insulation or lining. Units shall comply with UL 181, NFPA 90-A and shall meet bacteriological standard ASTM-665 for model resistance and burning characteristics ASTM-84 for flame spread and smoke developed.
6. The order of components in the direction of airflow shall be as follows:
  - a. Supply Units: Inlet duct connection/flow measuring assembly/opposed blade damper/outlet duct connection.
  - b. Return Units: Inlet connection/flow measuring assembly/opposed blade damper/outlet connection.

## 2.05 SINGLE DUCT TERMINAL UNIT CONTROLS

### A. DDC Controls

1. Terminal unit controls, transformers and actuators shall be DDC, furnished and shipped to the box manufacturer by the ATC Contractor. The ATC Contractor shall be responsible for all costs associated with shipping the controls to the terminal box manufacturing facility. Box damper actuators, transformers and controller shall be installed by the box manufacturer. The box manufacturer shall factory mount and wire the controller and actuator in accordance with the ATC Contractor's instructions. Controller installation costs shall be borne by the airflow terminal box manufacturer. Box manufacturer shall provide velocity inlet probe and NEMA control cover. **Note:** Controller and actuator specified in ATC.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The air terminal boxes shall be installed in accordance with manufacturer recommendations, Contract Drawings and reviewed submittals.
- B. The inlet duct size shall be as noted on the plans and/or the schedule. Air terminal boxes shall be connected to the sheet metal per requirements found herein under "Sheet Metal Work" Section.



- C. Terminal boxes shall be installed with adequate service space to access the controller side of the unit and the reheat coil control valve.
- D. Provide an access door in ductwork downstream of heating coil in addition to access door on unit upstream of coil. Label all access doors in accordance with labels specified under "Sheet Metal Installation" Section.
- E. Support each box adequately and independently without blocking access doors, control instrument access, or any other required access.

**END OF SECTION 23 36 00**

## **SECTION 233700 – REGISTERS, GRILLES AND DIFFUSERS**

### **PART 1 - GENERAL**

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

#### 1.02 WORK INCLUDED

- A. Furnish and install all registers, grilles and diffusers including opposed blade dampers, frames and other accessories to make a complete system of air distribution.
- B. All materials shall be new and manufactured for the specific purpose of distributing and controlling air flow.

#### 1.03 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

#### 1.04 REFERENCES

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.
- B. Material standards shall be as specified or detailed hereinafter and as following:
  1. ADC 1062: GRD – Test Code for Grilles, Registers and Diffusers; 1984.
  2. AMCA 500 – Test Method for Louvers, Dampers and Shutters; 1989.
  3. ASHRAE 70 – Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.
  4. NFPA 90A – Installation of Air Conditioning and Ventilating Systems; 1993.
  5. SMACNA (DCS) – HVAC Duct Construction Standard – metal and Flexible; 1995.

#### 1.05 SUBMITTALS

- A. See Section 2300500 and General Conditions for additional requirements.
- B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application and noise level.
- C. Project Record Documents: Record actual locations of air outlets and inlets.
- D. Submit air terminal performance data including static pressure, throw, velocity, airflow and acoustical performance. Data must indicate compliance with referenced Codes and Standards specified herein.

- E. Manufacturer shall review requirements of outlets as to size, finish and type of mounting before submitting shop drawings and schedule of outlets.
- F. Manufacturer shall check location of outlets and make necessary adjustments in position to conform with architectural features, symmetry and lighting arrangement before submitting shop drawings.

1.06 QUALITY ASSURANCE

- A. Manufacturer shall certify cataloged performance and ensure correct application of air outlet types.
- B. Manufacturer shall be responsible for examining application of each outlet and shall guarantee that each will provide comfortable space conditions without drafts at noted capacity.

**PART 2 - PRODUCTS**

2.01 GENERAL

- A. Acceptable manufacturers contingent on compliance with specifications.
  - 1. Anemostat
  - 2. Krueger
  - 3. Tuttle & Bailey
  - 4. MetalAire
  - 5. Price
  - 6. Nailor
  - 7. Titus
  - 8. Price
- B. All air distribution devices shall be of steel or aluminum construction unless otherwise specified herein or scheduled on the drawings.
- C. Distribution devices, except where such devices are specified or scheduled to be anodized extruded aluminum, shall be factory primed and finish painted by the manufacturer in a color as approved by the Architect during shop drawing review, unless otherwise noted.
- D. **All diffusers, grilles and registers and associated frames and margins must be compatible with the designed ceiling/wall type into which they are installed. Refer to architectural drawings for exact details of ceiling/wall construction.**

2.02 DIFFUSERS, REGISTERS AND GRILLES SHALL BE OF TYPE AS HEREIN SPECIFIED

| Designation | Service                         | Air Pattern                           |
|-------------|---------------------------------|---------------------------------------|
| A           | Supply                          | 1-way                                 |
| B           | Supply                          | 2-way (90°)                           |
| C           | Supply                          | 2-way (180°)                          |
| D           | Supply                          | 3-way                                 |
| E           | Supply                          | 4-way                                 |
| F           | Return/Exhaust                  | 45° Deflection                        |
| G           | Sidewall Supply<br>(Adjustable) | 45° Deflection<br>(Double Deflection) |
| H           | Low Wall Return/Exhaust         | ---                                   |

| Designation | Service                 | Air Pattern |
|-------------|-------------------------|-------------|
| J           | A-E Matched Return      |             |
| L1          | Linear Slot             | ---         |
| N           | Non-Aspirating Diffuser | ---         |

- A. Types A, B, C, D and E (Ceiling Supply)
- Ceiling or sidewall supply air diffusers of the above types shall be of the restricted multi-orifice jet induction and air mixing type, consisting of louvered sections with built-in diffusing vanes, similar to Tuttle & Bailey Type RCLT.
  - The vanes shall be arranged to discharge air from adjacent channels at a 45° angle in opposite directions to the plane of discharge to ensure rapid mixing of primary and room air. Each individual diffusing vane shall be welded in (2) places to the adjacent louver sections to make a rigid integral unit. The vanes shall extend to the discharge edges of the louvers.
  - Where louver sections abut core frame, the louver ends shall be welded to core frame. The louver ends shall be rounded and hemmed before welding to core frames.
  - Diffusers shall be square or rectangular, as shown on the drawings. Diffusers shall be assembled in patterns which provide 1-way, 2-way, 3-way or 4-way air discharge with each side delivering a quantity of air proportional to the area served. Diffusers shall be fabricated of steel welded or aluminum construction. The diffusers shall be provided with a removable core permitting easy access to the neck connection.
  - The diffusers shall be constructed with an integral collar extending at least 1" above the core **to accommodate an internal duct connection**. Collar corners shall have welded angles on the outside to prevent leakage and ensure that internal duct connection can be made secure.
- B. Type F (Return and Exhaust)
- General return/exhaust registers shall be similar to Tuttle & Bailey Model T77D and shall be made of steel or aluminum with (1) set of fixed blades, 42° deflection. Provide with countersunk holes and suitable frame to match ceiling or wall construction.
  - All return and exhaust registers installed in all toilet rooms, laundry rooms, showers and other areas subject to moisture shall be similar to above except constructed of all aluminum, equal to Tuttle & Bailey Model A77D.
- C. Type G (Sidewall Adjustable Supply)
- Sidewall supply registers shall be similar to Tuttle & Bailey Model T547 and shall be made of steel or aluminum, with mitered corners, double adjustable deflection core, and horizontal front louvers. Frames shall be suitable for construction adjacent to where registers are to be installed. Registers shall have countersunk screw holes.
- D. Type H (Low Wall Return/Exhaust)
- Low wall return/exhaust registers shall be similar to above except frame and blade shall be manufactured of heavy gauge steel or extruded aluminum (minimum thickness 12 gauge) for rugged use similar to Tuttle & Bailey Model 117DG.
- E. Type I (Not Used)
- F. Type J (Ceiling Return Grilles Matching Type A-E)
- Type J return grilles shall be as specified above for supply diffuser Types A through E.
  - Matching return grilles shall be located as indicated on the drawings.

G. Type L1 (Linear Slot Supply and Return)

1. Type L1 slot diffusers shall be similar to Air Factors, or Metalaire formations, with factory furnished plenum assembly.
2. Slot diffusers shall have a single slot (unless shown otherwise) and shall present a uniform appearance when used for supply air/return air, closed (blank off) or any of these combinations. Slot diffusers shall fully integrate with the specified ceiling systems and type noted. The pattern controllers shall also act as blank offs for any section without additional material. The slot diffuser lengths indicated on the mechanical drawings are active sections. For installed lengths of slot diffusers refer to architectural drawings.
3. Slot diffusers shall have two U-shaped channel pattern controllers supported with spacer channels in 24" (nominal) increments the entire length of the slot. The pattern controllers shall allow infinite adjustments to the air stream at 24" intervals relative to the direction of the air stream as well as extending or reducing the air throw, as may be required to satisfy job conditions and to provide draft-free air distribution. The slot diffusers shall maintain airflow across the ceiling and not dump within 10% of design CFM.
  - a. Fixed or blade type pattern controllers are not acceptable. Pattern controllers shall be heavy gauge steel painted flat black. One piece pattern controllers will not be accepted. The manufacturer of the air distribution system shall provide pattern controller setting gauges for the proper air quantity and control balancing purposes. For slot systems, adjustable hanger clips shall be provided to secure the diffusers to the structure. Screws through the flanges will not be allowed.
  - b. Splice clips shall be provided on both sides of the diffusers at each joint. Alignment clips shall be provided on both sides of the diffusers at splice connections. To secure the diffusers to the ceiling suspension, provide custom design clips.
4. All interior portions of the slot shall be painted flat black. All exposed flanges for the diffusers shall be painted to match the ceiling system.
5. Supply/return air plenums shall be 26-gauge (minimum) galvanized sheet metal, utilizing a seam assembly allowing less than one percent casing leakage. Sheet metal plenums shall be field insulated. All surfaces visible through the diffuser slot will be painted flat black. The plenum shall be secured to the slot diffuser with four spring steel clips. Hanger clips shall be provided for both top ends of the plenum to secure the plenum to the building structure. The plenum shall have a round air entry collar sized at a maximum air entry velocity of 750 FPM. Air proportioning vanes for top inlet plenum shall be provided. Where shown on the mechanical plan, provide a remote control damper assembly, adjustable through the linear spacer assembly in non-accessible ceilings. Damper system shall be preassembled at the factory.
6. Slot diffusers shall be fully compatible with the surfaces in which they are installed and shall be provided with all the required mounting accessories for installation in the actual construction at the installed location.
7. Coordinate integration of linear air distribution installation with the structural framing of the ceiling panel system to verify border style, slot size, overall length and end conditions for each run.
8. Linear Diffuser Slot Width Selection Criteria Schedule:

| <u>Space Type</u> | <u>Max. Diffuser NC</u> |
|-------------------|-------------------------|
| Break Room        | 30                      |
| Office            | 30                      |

- H. Type N (Non-Aspirating Ceiling Supply)
  - 1. Radial pattern diffusers shall be Tuttle & Bailey Model Vector, Metal-Aire, or Titus TAD.
  - 2. Installed units shall provide a flush line with ceiling system, non-flush face diffuser are not acceptable. The unit shall consist of a diffuser face assembly and a diffuser back assembly. The diffuser face assembly must be assembled into the diffuser back assembly and be delivered ready to install. The diffuser face assembly shall feature a combination of engineered longitudinal louvers and perforated sheet metal, oriented and proportional in a manner to provide either a 90 degree or 180 degree radial, non-aspirating air flow pattern. The perforated sheet metal shall consist of 5/32" diameter holes on 1/4" centers on 2' lengths or 3/16" diameter holes on 1/4" centers on 4' lengths. The diffuser face assembly shall be removable with common tools. It must be hinged on one side and secured in place with quarter-turn fasteners on the opposing side.
  - 3. The diffuser back assembly shall be fabricated as a fully assembled single unit, consisting of the back frame, an integral diffusion baffle specifically designed for each size and air pattern, and a 2" high collar complete with locking bead for positive duct connection.
  - 4. Engineering data shall be based upon tests conducted in accordance with ASHRAE Standard 70-1991, Method of Testing for Rating the Performance of Air Outlets and Inlets at non-isothermal conditions. Published Noise Criteria (NC) data shall be determined based upon a 10 ddB room attenuation across all octave bands. Lab test reports shall be available upon request.
  
- I. Air Screens/Wire Mesh
  - 1. Mesh shall be 3/4" square pattern, 1/16" galvanized wire, interwoven, welded or secured to frame.
  - 2. Frames shall be 1" by 1" by 1/8" galvanized steel angles for duct sizes through 24"; 1 1/2" x 3/16" for duct sizes between 25" and 48"; and, 2" by 2" by 3/16" for ducts larger than 48", continuous around perimeter of screen.

### **PART 3 - INSTALLATION**

#### **3.01 INSTALLATION**

- A. Install in accordance with manufacturer's instruction.
- B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry and lighting arrangement.
- C. Install diffusers to ductwork with air tight connections.
- D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- E. Paint ductwork visible behind air outlets and inlets matte black.

**END OF SECTION 23 37 00**