

SECTION 23 22 16
STEAM AND CONDENSATE PIPING SPECIALTIES

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Steam traps.
 2. Steam air vents.

1.2 REFERENCES

- A. American Society of Mechanical Engineers:
1. ASME B40.1 - Gauges - Pressure Indicating Dial Type - Elastic Element.
 2. ASME Section VIII - Boiler and Pressure Vessel Code - Pressure Vessels.
- B. ASTM International:
1. ASTM A105/A105M - Standard Specification for Carbon Steel Forgings for Piping Applications.
 2. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 3. ASTM A216/A216M - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
 4. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
- C. Underwriters Laboratories Inc.:
1. UL 393- Indicating Pressure Gauges for Fire-Protection Service.
 2. UL 404 - Gauges, Indicating Pressure, for Compressed Gas Service.

1.3 PERFORMANCE REQUIREMENTS

- A. Steam Traps:
1. Select to handle minimum of two times maximum condensate load of apparatus served.
 2. Pressure Differentials:
 - a. Medium Pressure Steam (25 psi maximum): 5 psi.
 - b. Medium Pressure Steam (60 psi maximum): 15 psi.
 - c. High Pressure Steam (150 psi maximum): 40 psi.

1.4 SUBMITTALS

- A. Submittal procedures. As specified in Division 1.
- B. Product Data: Submit for manufactured products and assemblies used in this Project.
1. Manufacturer's data and list indicating use, operating range, total range, accuracy, and location for manufactured components.

2. Submit product description, model, dimensions, component sizes, rough-in requirements, service sizes, and finishes.
3. Submit schedule indicating manufacturer, model number, size, location, rated capacity, load served, and features for each piping specialty.
4. Submit connection requirements.

C. Manufacturer's Installation Instructions: Submit hanging and support methods, joining procedures, application, selection, and hookup configuration. Include pipe and accessory elevations.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.5 CLOSEOUT SUBMITTALS

- A. Closeout procedures. As specified in Division 1

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Product storage and handling requirements. As specified in Division 1.
- B. Provide temporary protective coating on cast iron and steel valves.
- C. Protect systems from entry of foreign materials by temporary covers, caps and closures, completing sections of the work, and isolating parts of completed system until installation.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Product Requirements. As specified in Division 1.
- B. Do not install instruments when areas are under construction, except rough in, taps, supports and test plugs.

1.8 FIELD MEASUREMENTS

- A. Verify field measurements before fabrication.

1.9 WARRANTY

- A. Product warranties and product bonds. As specified in Division 1.

1.10 MAINTENANCE MATERIALS

- A. Spare parts and maintenance materials. As specified in Division 1.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. The following manufacturers are acceptable:

1. Armstrong
2. Spirax-Sarco
3. Watson McDaniel

2.2 FLOAT AND THERMOSTATIC TRAPS

A. Trap:

1. Construction: ASTM A126, cast iron body and bolted cover, stainless steel or bronze bellows type air vent, stainless steel or copper float, stainless steel lever and valve assembly
2. Rating: 300 psig WSP.
3. Features: Access to internal parts without disturbing piping, bottom drain plug.
4. Accessories: Gage glass with shut-off cocks.

2.3 THERMODYNAMIC TRAPS

A. Trap:

1. Construction: Stainless steel body, disc, and cap.
2. Rating: 300 psig WSP.
3. Features: Stainless steel insulating cap 1/4 inch steel blow down valve integral strainer.

2.4 THERMOSTATIC TRAPS

A. Pressure Balanced:

1. Trap: ASTM A395/A395M cast iron body and bolted or screwed cover and integral ball joint union for 225 psig Stainless steel bellows, stainless steel valve and seat; integral stainless steel strainer.

B. Bimetallic:

1. Trap: ASTM A105/A105M forged steel body and cover, for 300 psig WSP, bimetal element with stainless steel components, integral Type 304 stainless steel strainer screen, 1/4 inch blow down valve.

2.5 STEAM AIR VENTS

A. 125 psig WSP:

1. Balanced Pressure Type: Cast brass body and cover; access to internal parts without disturbing piping; stainless steel bellows, stainless steel valve and seat.

PART 3 EXECUTION

3.1 INSTALLATION - GAGES

- A. Install pressure gages with pulsation dampers. Provide ball valve to isolate each gage. Install siphon on gages in steam systems. Extend nipples and siphons to allow clearance from insulation.
- B. Provide instruments with scale ranges selected according to service with largest appropriate scale.

- C. Install gages in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- D. Adjust gages to final angle, clean windows and lenses, and calibrate to zero.

3.2 INSTALLATION - STEAM SYSTEM SPECIALTIES

- A. Steam Traps:
 - 1. Provide minimum 3/4 inch size on steam mains and branches.
 - 2. Install with union or flanged connections at both ends.
 - 3. Provide gate valve and strainer at inlet, and gate valve and check valve at discharge.
 - 4. Provide minimum 10 inch long, line size dirt pocket between apparatus and trap.
- B. Install thermostatic steam traps on the following pieces of equipment:
 - 1. Convectors.
 - 2. Other similar terminal heating units.

- C. Install float and thermostatic steam traps on the following pieces of equipment:
 - 1. Heat exchangers.
 - 2. Steam separators.
 - 3. Flash tanks.
 - 4. Process equipment.
 - 5. Main headers.
 - 6. Branch lines.
- D. Install inverted bucket steam traps on the following pieces of equipment:
 - 1. Main headers.
 - 2. Branch lines.
- E. In high pressure and medium pressure mains, install 3/4 inch nipple in bottom of main, extending 3/4 inch into and above bottom of pipe. Provide dirt pocket with 1/2 inch high pressure thermostatic trap.
- F. Rate relief valves for pressure upstream of pressure reducing station, for full operating capacity. Set relief at maximum 20 percent above reduced pressure.
- G. Terminate relief valves to outdoors 2 feet minimum above roof. Provide drip pan elbow with drain connection to nearest floor drain.
- H. When connecting several relief valve vents to common header, size header cross sectional equal to sum of individual vent outlet areas.

3.3 PROTECTION OF INSTALLED CONSTRUCTION

- A. Requirements for protecting installed construction. As specified in Division 1.
- B. Remove thermostatic elements from steam traps during temporary and trial usage, and until system has been operated and dirt pockets cleaned of sediment and scale.
- C. Do not install steam pressure gauges until after systems are pressure tested.

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SECTION 23 31 00
HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Ductwork and accessories for HVAC including the following:
 - 1. Supply air, return air, outside air, exhaust, make-up air, and relief systems.
- B. Definitions:
 - 1. SMACNA Standards as used in this specification means the HVAC Duct Construction Standards, Metal and Flexible.
 - 2. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.
 - 3. Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
 - 4. Exposed Duct: Exposed to view in a finished room, exposed to weather.

1.2 RELATED WORK

- A. Fire Stopping Material: Section 07 84 00, FIRESTOPPING.
- B. Seismic Reinforcing: Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- C. General Mechanical Requirements: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Noise Level Requirements: Section 23 05 48, VIBRATION ISOLATION AND SEISMIC / WIND CONTROLS FOR HVAC PIPING AND EQUIPMENT.
- E. Duct Insulation: Section 23 07 11, HVAC INSULATION
- F. VAV Boxes: Section 23 36 00, AIR TERMINAL UNITS.
- G. Duct Mounted Coils: Section 23 82 16, AIR COILS.
- H. Fans: Section 23 34 00, HVAC FANS.
- I. Air Filters and Filters' Efficiencies: Section 23 40 00, HVAC AIR FILTERS.
- J. Duct Mounted Instrumentation: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- K. Testing and Balancing of Air Flows: Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- L. Smoke Detectors: Section 28 31 00, FIRE DETECTION and ALARM.

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Fire Safety Code: Comply with NFPA 90A.

- C. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.
- D. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA HVAC Air Duct Leakage Test Manual for duct pressure classes shown on the drawings.
- E. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Rectangular ducts:
 - a. Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, gage and reinforcement.
 - b. Sealants and gaskets.
 - c. Access doors.
 - 2. Round and flat oval duct construction details:
 - a. Manufacturer's details for duct fittings.
 - b. Sealants and gaskets.
 - c. Access sections.
 - d. Installation instructions.
 - 3. Volume dampers, back draft dampers.
 - 4. Upper hanger attachments.
 - 5. Fire dampers, fire doors, and smoke dampers with installation instructions.
 - 6. Sound attenuators, including pressure drop and acoustic performance.
 - 7. Flexible ducts and clamps, with manufacturer's installation instructions.
 - 8. Flexible connections.
 - 9. Instrument test fittings.

1.5 APPLICABLE PUBLICATIONS

- A. American Society of Civil Engineers (ASCE):
ASCE7-05.....Minimum Design Loads for Buildings and Other Structures
- B. American Society for Testing and Materials (ASTM):
A167-99 (2009).....Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

- A653-09.....Standard Specification for Steel Sheet,
Zinc-Coated (Galvanized) or Zinc-Iron Alloy
coated (Galvannealed) by the Hot-Dip process
- A1011-09a.....Standard Specification for Steel, Sheet and
Strip, Hot rolled, Carbon, structural, High-
Strength Low-Alloy, High Strength Low-Alloy with
Improved Formability, and Ultra-High Strength
- B209-07.....Standard Specification for Aluminum and
Aluminum-Alloy Sheet and Plate
- C1071-05e1.....Standard Specification for Fibrous Glass Duct
Lining Insulation (Thermal and Sound Absorbing
Material)
- E84-09a.....Standard Test Method for Surface Burning
Characteristics of Building Materials
- C. National Fire Protection Association (NFPA):
- 90A-09.....Standard for the Installation of Air
Conditioning and Ventilating Systems
- D. Sheet Metal and Air Conditioning Contractors National Association
(SMACNA):
- 2nd Edition - 2005.....HVAC Duct Construction Standards, Metal and
Flexible
- 1st Edition - 1985.....HVAC Air Duct Leakage Test Manual
- 6th Edition - 2003.....Fibrous Glass Duct Construction Standards
- E. Underwriters Laboratories, Inc. (UL):
- 181-08.....Factory-Made Air Ducts and Air Connectors
- 555-06Standard for Fire Dampers
- 555S-06Standard for Smoke Dampers

PART 2 - PRODUCTS

2.1 DUCT MATERIALS AND SEALANTS

- A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A653, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.
- B. Specified Corrosion Resistant Systems: Stainless steel sheet, ASTM A167, Class 304, Condition A (annealed) Finish No. 4 for exposed ducts and Finish No. 2B for concealed duct or ducts located in mechanical rooms.
- C. Joint Sealing: Refer to SMACNA HVAC Duct Construction Standards, paragraph S1.9.
1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally provide liquid sealant, with or without compatible tape, for low

clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.

2. Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used on bare metal or on dry sealant.

3. Gaskets in Flanged Joints: Soft neoprene.

D. Approved factory made joints may be used.

2.2 DUCT CONSTRUCTION AND INSTALLATION

A. Regardless of the pressure classifications outlined in the SMACNA Standards, fabricate and seal the ductwork in accordance with the pressure classifications shown on Drawings:

B. Seal Class: All ductwork shall receive Class A Seal.

C. Duct Materials:

1. Galvanized Steel Ducts: ASTM A653/A653M galvanized steel sheet, lock-forming quality, having G60 (zinc coating of in conformance with ASTM A90/A90M.
2. Stainless Steel Ducts: ASTM A240/A240M or ASTM A666, Type 304.
3. Fasteners: Rivets, bolts, or sheet metal screws.
4. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

2.3 SINGLE WALL SPIRAL ROUND DUCTS:

A. Manufacturers:

1. McGill AirFlow Corporation.
2. Semco Incorporated
3. Spiral Mfg. Co., Inc.
4. Dixie Sheet Metal
5. Eastern Sheet Metal
6. Hamlin Sheet Metal

B. Product Description: UL 181, Class 1, round spiral lockseam duct constructed of galvanized steel, rated for 10 inch WG positive pressure.

C. Construct duct with the following minimum gages:

Diameter	Gauge
3 inches to 14 inches	26
15 inches to 26 inches	24
28 inches to 36 inches	22
38 inches to 50 inches	20
52 inches to 84 inches	18

D. Construct fittings with the following minimum gages:

Diameter	Gauge
3 inches to 14 inches	24
15 inches to 26 inches	22
28 inches to 36 inches	20
38 inches to 50 inches	20
52 inches to 60 inches	18
62 inches to 84 inches	16

2.4 SINGLE WALL SPIRAL FLAT OVAL DUCTS

A. Manufacturers:

1. McGill AirFlow Corporation.
2. Semco Incorporated
3. Spiral Mfg. Co., Inc.
4. Hamlin Sheet Metal
5. Dixie Sheet Metal
6. Eastern Sheet Metal

B. Product Description: Machine made from round spiral lockseam duct constructed of galvanized steel; rated for 10 inches wg pressure.

C. Joints: either fully welded or bolted flange with gasket material in accordance with manufacturer's recommendations.

D. Construct duct with the following minimum gages:

Major Axis Dimension	Gauge
7 inches to 24 inches	24
25 inches to 48 inches	22
50 inches to 70 inches	20
72 inches to 82 inches	18
84 inches and larger	16

E. Construct fittings with the following minimum gages:

Major Axis Dimension	Gauge
7 inches to 36 inches	20
37 inches to 60 inches	18
62 inches and larger	16

2.5 DOUBLE WALL SPIRAL INSULATED ROUND DUCTS

A. Manufacturers:

1. McGill AirFlow Corporation.
2. Semco Incorporated
3. Spiral Mfg. Co., Inc.
4. Hamlin Sheet Metal

5. Dixie Sheet Metal

6. Eastern Sheet Metal

B. Product Description: Machine made from round spiral lockseam duct with light reinforcing corrugations, galvanized steel outer wall, 1 inch thick glass fiber insulation at 1.5 lb. / cu. ft., solid galvanized steel inner wall; fittings manufactured with solid inner wall.

C. Construct duct with the following minimum gages:

Diameter	Gauge
3 inches to 14 inches	26
15 inches to 26 inches	24
28 inches to 36 inches	22
38 inches to 50 inches	20
52 inches to 84 inches	18

D. Construct round fittings with the following minimum gages:

Diameter	Gauge
3 inches to 14 inches	24
15 inches to 26 inches	22
28 inches to 36 inches	20
38 inches to 50 inches	20
52 inches to 60 inches	18
62 inches to 84 inches	16

2.6 DOUBLE WALL SPIRAL INSULATED FLAT OVAL DUCTS

A. Manufacturers:

1. McGill AirFlow Corporation.
2. Semco Incorporated
3. Spiral Mfg. Co., Inc.
4. Hamlin Sheet Metal
5. Dixie Sheet Metal
6. Eastern Sheet Metal

B. Product Description: Machine made from round spiral lockseam duct with light reinforcing corrugations, galvanized steel outer wall, 1-inch thick glass fiber insulation at 1.5 lb. / cu. ft., solid galvanized steel inner wall; fittings manufactured with solid inner wall.

C. Construct flat oval duct with the following minimum gages:

Major Axis Diameter	Gauge
7 inches to 24 inches	24

25 inches to 48 inches	22
50 inches to 70 inches	20
72 inches to 82 inches	18
84 inches and larger	16

D. Construct flat oval fittings with the following minimum gages:

Major Axis Fitting Dimension	Gauge
7 inches to 36 inches	20
37 inches to 60 inches	18
62 inches and larger	16

2.7 DUCTWORK FABRICATION

- A. Fabricate and support rectangular ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and as indicated on Drawings. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- B. Construct T's, bends, and elbows with minimum radius 1-1/2 times centerline duct width. Where not possible and where rectangular elbows are used, provide airfoil turning vanes. Where acoustical lining is indicated, furnish turning vanes of perforated metal with glass fiber insulation.
- C. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- D. Fabricate continuously welded round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Minimum 4 inches cemented slip joint, brazed or electric welded. Prime coat welded joints.
- E. Provide standard 45-degree lateral wye takeoffs. When space does not allow 45-degree lateral wye takeoff, use 90-degree conical tee connections.
- F. Seal joints between duct sections and duct seams with welds, gaskets, mastic adhesives, mastic plus embedded fabric systems, or tape.
 1. Sealants, Mastics and Tapes: Conform to UL 181A. Provide products bearing appropriate UL 181A markings.
 2. Do not provide sealing products not bearing UL approval markings.

2.8 ISOLATION EXHAUST DUCTWORK FABRICATION

Ductwork shall be designed and tested for 60 inches water column minimum and shall be prefabricated as described herein.

- A. The isolation exhaust duct shall be of the round single-wall factory-built type with flanged ends. Joints between adjacent sections of pipe

shall be mechanically connected by means of a formed Vee-Band and sealed with Type P077 Silicone Sealant to assure liquid tight joints.

- B. Pipe and fitting shall be formed of Type 316 stainless steel, 0.035" thick with seams continuously seal welded.
- C. Filter and/or fan transitions shall be provided by the duct manufacturer and shall be fabricated from the same material as the round ductwork.
- D. All supports, drains, caps, exit zones, fittings expansion joints, and accessories required to install the fume exhaust duct, routed as indicated on the plans, shall be included.
- E. Isolation exhaust ductwork shall be Model PSW Pressure Pipe as manufactured by Metal-Fab, inc. or equal.

2.9 FLEXIBLE AIR DUCT

- A. General: Factory fabricated, complying with NFPA 90A for connectors not passing through floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance rating of one hour or more. Flexible duct length shall not exceed 5 feet. Provide insulated acoustical air duct connectors in supply air duct systems.
- B. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181, Class 1.
- C. Factory made including mineral fiber insulation with maximum C factor of 75 degrees F mean temperature, helical wound spring steel wire, aluminum laminate, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units.
- D. Application Criteria:
 - 1. Temperature range: 0 to 200 degrees F internal.
 - 2. Maximum working velocity: 4000 feet per minute.
 - 3. Minimum working pressure, inches of water gage: 10 inches positive, 2 inches negative.
- E. Duct Clamps: 100 percent nylon strap, 175 pounds minimum loop tensile strength manufactured for this purpose or stainless steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.
- F. Insulated Flexible Ducts:
 - 1. Supply, return, and exhaust grill final connections: As an option to square duct or spiral lockseam round duct (both externally insulated for supply and return), the contractor may submit product for flexible duct connections that complies with the requirements outlined below. Contractor shall not use more than 5-ft. of approved product for final connections.
 - 2. Manufacturers:

- a. Flexmaster Type 1MR6
- b. Approved equal.
3. Core material shall be an acoustical transparent PE fabric supported by helically wound galvanized steel. The fabric shall be mechanically fastened to the steel helix without the use of adhesive. The core shall maintain its free area at a center line radius of 1.0 or better.
4. The internal working pressure rating shall be at least as follows with a bursting pressure of at least 2-1/2 times the working pressure.
 - a. Positive: 10 inches W.G. thru 20" diameter
 - b. Negative: 5 inches W.G. thru 16" diameter.
5. The duct shall be rated for a velocity of at least 5500 feet per minute.
6. Suitable for operating temperatures of at least 250 degrees F.
7. Minimum Acoustic Performance:
 - a. The insertion loss (dB) of a 6 foot length of duct when tested in accordance with ASTM E 477 at a velocity of 1000 feet per minute shall be at least:

	<u>125 Hz</u>	<u>250 Hz</u>	<u>500 Hz</u>	<u>1000 Hz</u>	<u>2000 Hz</u>	<u>4000 Hz</u>
1) 8 inch dia.	5	10	22	34	22	17
2) 12 inch dia.	6	27	22	28	18	11

8. Product to be factory insulated with flexible fiberglass insulation, with R-value at least 6.0 at a mean temperature of 75 degrees F.
9. Product to include a reinforced aluminum pigmented vapor barrier jacket having a permeance of not greater than 0.05 perms when tested in accordance with ASTM E 96, procedure A.
10. The ductwork shall be UL 181 listed, Class 1 Air Duct and comply with NFPA 90A and 90B.

2.10 FLEXIBLE DUCT CONNECTIONS

Where duct connections are made to fans, air terminal units, and air handling units, install a non-combustible flexible connection of 30 oz. / sq. yd. neoprene coated fiberglass fabric approximately 6 inches wide. For connections exposed to sun and weather provide hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A 240 lbs. x 220 lbs. tensile strength, 100 lbs. x 100 lbs. tear strength. Securely fasten flexible connections to round ducts with stainless steel or zinc-coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts

by screws 2 inches on center. Fabric shall not be stressed other than by air pressure. Allow at least one inch slack to insure that no vibration is transmitted. Provide Duro Dyne MBX or approved equal.

2.11 PREFABRICATED ROOF CURBS

Galvanized steel or extruded aluminum 12 inches above finish roof service, continuous welded corner seams, treated wood nailer, 1-1/2 inch thick, 3 pound/cubic foot density rigid mineral fiberboard insulation with metal liner, built-in cant strip (except for gypsum or tectum decks). For surface insulated roof deck, provide raised cant strip (recessed mounting flange) to start at the upper surface of the insulation. Curbs shall be constructed for pitched roof or ridge mounting as required to keep top of curb level.

2.12 FIRESTOPPING MATERIAL

Refer to Section 07 84 00, FIRESTOPPING.

2.13 SEISMIC RESTRAINT FOR DUCTWORK

Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.14 DUCT MOUNTED THERMOMETER (AIR)

- A. Stem Type Thermometers: ASTM E1, 7 inch scale, red appearing mercury, lens front tube, cast aluminum case with enamel finish and clear glass or polycarbonate window, brass stem, 2 percent of scale accuracy to ASTM E77 scale calibrated in degrees Fahrenheit.
- B. Thermometer Supports:
 - 1. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
 - 2. Flange: 3 inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.15 INSTRUMENT TEST FITTINGS

- A. Manufactured type with a minimum two inch length for insulated duct, and a minimum one inch length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.
- B. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

2.16 ELECTROSTATIC SHIELDING

- A. At the point of penetration of shielded rooms ducts shall be made electrically discontinuous by means of a flexible, nonconductive connection outside shielded room.

- B. Metallic duct portion inside shielded room shall be electrically bonded to shielding.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, particularly regarding coordination with other trades and work in existing buildings.
- B. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:
 - 1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
 - 2. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards, Section II. Provide streamliner, when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.
 - 3. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA Standards.
 - 4. Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards, Chapter 6. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.
- C. Install duct hangers and supports in accordance with SMACNA Standards, Chapter 4.
- D. Install fire dampers, smoke dampers and combination fire/smoke dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test. Install fire dampers, smoke dampers and combination fire/smoke dampers at locations indicated and where ducts penetrate fire rated and/or smoke rated walls, shafts and where required by the Resident Engineer. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges per UL and

- NFPA. Demonstrate re-setting of fire dampers and operation of smoke dampers to the Resident Engineer.
- E. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.
- F. Flexible duct installation: Refer to SMACNA Standards, Chapter 3. Ducts shall be continuous, single pieces not over 5 feet long (NFPA 90A), as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with clamps as recommended by SMACNA. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated one hour or two hour. Support ducts SMACNA Standards.
- G. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black
- H. Control Damper Installation:
1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
 2. Assemble multiple sections dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.
 3. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.
 4. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.
- I. Air Flow Measuring Devices (AFMD): Install units with minimum straight run distances, upstream and downstream as recommended by the manufacturer.
- J. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as determined by Resident Engineer. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2 DUCT LEAKAGE TESTS AND REPAIR

- A. Ductwork leakage testing shall be performed by the Mechanical Contractor and witnessed by VAMC and project engineer.
- B. Ductwork leakage testing shall be performed for the entire air distribution system (including all supply, return, exhaust and relief ductwork), section by section, including fans, coils and filter sections. Based upon satisfactory initial duct leakage test results, the scope of the testing may be reduced by the Resident Engineer on ductwork constructed to the 2" WG duct pressure classification. In no case shall the leakage testing of ductwork constructed above the 2" WG duct pressure classification or ductwork located in shafts or other inaccessible areas be eliminated.
- C. Test procedure, apparatus and report shall conform to SMACNA Leakage Test manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.
- D. All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.
- E. All tests shall be performed in the presence of the Resident Engineer and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the Resident Engineer and identify leakage source with excessive leakage.
- F. If any portion of the duct system tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of ductwork to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the Resident Engineer.
- G. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.
- H. Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.

3.3 DUCTWORK EXPOSED TO WIND VELOCITY

Provide additional support and bracing to all exposed ductwork installed on the roof or outside the building to withstand wind velocity of 90 mph.

3.4 TESTING, ADJUSTING AND BALANCING (TAB)

Refer to Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

3.5 OPERATING AND PERFORMANCE TESTS

Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

3.6 TESTING

- A. Ductwork to be pressure tested as outlined on drawing. This testing to be based on construction and pressure test classification, allowable leakage and percentage of ductwork to be tested.
- B. All duct work testing to be observed by test and balance contractor and/or owner's representative. Completion of test and setup including calibrated test unit, to be provided by mechanical contractor.
- C. Mechanical Contractor to coordinate and schedule test observation. Prior to observance of duct testing, mechanical contractor to pretest duct and resolve issues contributing to non-conformance.
- D. Mechanical Contractor to provide submittal of test unit being used, including calibration certification, and duct plan indicating how duct systems to be tested. Mechanical contractor to provide calculations for each section of duct to be tested, per SMACNA HVAC Air Duct Leakage Test Manual.

- - - E N D - - -

SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Duct access doors
 - 2. Static fire dampers
 - 3. Dynamic fire dampers
 - 4. Volume control dampers
 - 5. Fire smoke dampers
 - 6. Smoke dampers.
 - 7. Sound attenuators

1.2 REFERENCES

- A. Air Movement and Control Association International, Inc.:
 - 1. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.
- B. ASTM International:
 - 1. ASTM E1 - Standard Specification for ASTM Thermometers.
- C. National Fire Protection Association:
 - 1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
 - 2. NFPA 92A - Recommended Practice for Smoke-Control Systems.
 - 3. NFPA 101 - Life Safety Code
- D. Sheet Metal and Air Conditioning Contractors:
 - 1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.
- E. Underwriters Laboratories Inc.:
 - 1. UL 555 - Standard for Safety for Fire Dampers.
 - 2. UL 555C - Standard for Safety for Ceiling Dampers
 - 3. UL 555S - Standard for Safety for Smoke Dampers

1.3 SUBMITTALS

- A. Submittal procedures. As specified in Division 1.
- B. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers, and duct access doors.
- C. Product Data: Submit data for shop fabricated assemblies and hardware used.
- D. Product Data: Submit for the following. Include where applicable electrical characteristics and connection requirements.
 - 1. Fire dampers including locations and ratings.
 - 2. Smoke dampers including locations and ratings.

3. Flexible duct connections.
4. Volume control dampers.
5. Duct access doors.
6. Duct test holes.

E. Product Data: For fire dampers, smoke dampers, combination fire and smoke dampers, and backdraft dampers submit the following:

1. Include UL ratings, dynamic ratings, leakage, pressure drop, maximum pressure data and maximum back pressure data.
2. Indicate materials, construction, dimensions, and installation details.
3. Verify damper pressure drop ratings based on tests and procedures performed in accordance with AMCA 500.

F. Manufacturer's Installation Instructions: Submit for Fire and Combination Smoke and Fire Dampers.

G. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

- A. Closeout procedures. As specified in Division 1
- B. Operation and Maintenance Data: Submit for Combination Smoke and Fire Dampers.

1.5 QUALITY ASSURANCE

- A. Dampers tested, rated and labeled in accordance with the latest UL requirements.
- B. Damper pressure drop ratings based on tests and procedures performed in accordance with AMCA 500.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Product storage and handling requirements. As specified in Division 1.
- B. Protect dampers from damage to operating linkages and blades.
- C. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.
- D. Storage: Store materials in a dry area indoor, protected from damage.
- E. Handling: Handle and lift dampers in accordance with manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage.

1.7 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.8 COORDINATION

- A. Coordination and project conditions. As specified in Division 1.
- B. Coordinate Work where appropriate with building control Work.

1.9 WARRANTY

- A. Product warranties and product bonds. As specified in Division 1.
- B. Furnish one year manufacturer warranty for duct accessories.

1.10 EXTRA MATERIALS

- A. Spare parts and maintenance products. As specified in Division 1

PART 2 PRODUCTS

2.1 DUCT ACCESS DOORS

- A. Manufacturers:
 - 1. Ruskin
 - 2. Greenheck
- B. Fabrication: Rigid and close fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, furnish minimum 1 inch thick insulation with sheet metal cover.
 - 1. Minimum 22 gauge roll formed galvanized steel with installation tabs. Match access door type with ductwork other than galvanized, stainless steel, aluminum, etc.
 - 2. Locks:
 - a. Manually operated cam
 - b. Doors 16" and under have two locks
 - c. Doors over 16" have four locks
 - 3. Insulation: Minimum 1 inch thick fiberglass for all insulated duct.
 - 4. Seals: Foam gasket, between door and frame and between frame and duct
 - 5. Access panels with sheet metal screw fasteners are not acceptable.
- C. Models
 - 1. Equal to Ruskin ADC22 for Rectangular Insulated Duct
 - 2. Equal to Ruskin ADC12 for Rectangular Non-Insulated Duct
 - 3. Equal to Ruskin ADF for Oval Duct
 - 4. Equal to Ruskin ADR for Round Duct

2.2 STATIC FIRE DAMPERS

- A. Manufacturers:
 - 1. Ruskin
 - 2. Greenheck
- B. Fire Rating: UL 555 classified and labeled as a 1-1/2 hour static fire damper.
- C. Air Flow Rating: UL approved for dual directional air flow.
- D. Integral Sleeve Frame: Minimum 20 gage by 12 inches roll formed, galvanized steel.

1. Factory Sealant: Apply to dampers in HVAC systems with pressures to maximum 4 inches wg.

E. Blades:

1. Style: Curtain type, in airstream.
2. Action: Spring or gravity closure upon fusible link release.
3. Orientation: Horizontal.
4. Material: Minimum 24 gage roll formed, galvanized steel.

F. Closure Springs: Type 301 stainless steel, constant force type, if required.

G. Temperature Release Device:

1. Fusible link, 165 degrees F.
2. Mounting: Vertical or horizontal.

H. Duct Transition Connection, Damper Style:

1. A style - rectangular connection, frame and blades in air stream.
2. B style - rectangular connection, blades out of air stream, high free area.
3. G style - A style connection, grille mounting tabs at end of sleeve for grille.
4. R style - round connection, blades in air stream, non-sealed.
5. RA style - round connection, frame, and blades in air stream.
6. LR style - round connection, blades out of air stream, non-sealed.
7. LO style - oval connection, non-sealed.

I. Finish: Mill galvanized.

J. Picture Frame Mounting Angles:

1. One-piece, roll formed retaining angles.
2. Factory matched and shipped attached to damper.

2.3 DYNAMIC FIRE DAMPERS

A. Manufacturers:

1. Ruskin
2. Greenheck

B. Fabricate in accordance with NFPA 90A and UL 555.

C. Fire Resistance: 1-1/2 hours in accordance with UL 555

D. Dynamic Closure Rating: Dampers classified for dynamic closure to 2000 fpm and 4 inches wg static pressure.

E. Construction:

1. Integral Sleeve Frame: Minimum 20 gauge roll formed galvanized steel. Length 12 inches.
2. Blades:
 - a. Style: Curtain type.

- b. Action: Spring closure upon fusible link release.
- c. Material: Minimum 24 gage roll formed, galvanized steel.
- 3. Closure Springs: Type 301 stainless steel, constant force type, if required.
- F. Fusible Link Release Temperature: 165 degrees F.
- G. Mounting: Vertical or horizontal as indicated on Drawings.
- H. Mounting Angles: Provide with one piece factory pre-punched screw holes. Provide with two mounting angles, 1-1/2" x 1-1/2", equal to Ruskin PFMA.
- I. Finish: Mill galvanized
- J. Models:
 - 1. Equal to Ruskin DIBD20 "B" Style for rectangular duct
 - 2. Equal to Ruskin DIBD20 "G" Style for rectangular duct and grille mounting tabs at end of sleeve for grille.
 - 3. Equal to Ruskin DIBD20 "CO" Style for oval duct
 - 4. Equal to Ruskin FDR25 for round duct

2.4 VOLUME CONTROL DAMPERS

- A. Manufacturers:
 - 1. Ruskin
 - 2. Greenheck
 - 3. Jenn-Air
 - 4. Crown
 - 5. Flexmaster
- B. Splitter Dampers:
 - 1. Material: Same gage as duct to 24 inches size in both dimensions, and two gages heavier for sizes over 24 inches.
 - 2. Blade: Fabricate of double thickness sheet metal to streamline shape, secured with continuous hinge or rod.
 - 3. Operator: Minimum 1/4 inch diameter rod in self aligning, universal joint action, flanged bushing with set screw.
 - 4. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.
- C. Rectangular Manual Volume Dampers
 - 1. 1. Frame: 22 gauge galvanized steel 3" wide or 5" X 1" X 18 gauge galvanized steel channel with corner braces.
 - 2. Blades: 22 gauge galvanized steel single blade or 18 gauge galvanized steel 8" maximum width.
 - a. Dampers larger than 36" wide or 12" high shall be multiple blade dampers.
 - 3. Bearings: Corrosion resistant, molded synthetic and axles shall positively lock into the damper blade.
 - 4. Pressure Rating: 2-1/2" wg at 1,500 fpm for 48" wide damper.
 - 5. Standoff: Factory installed 2" hand quadrant stand-off bracket.
 - 6. Model: Equal to Ruskin MD15.
- D. Round Inline Manual Volume Dampers:
 - 1. Frame: 20 gauge galvanized steel, 6" wide.
 - 2. Blades: 20 gauge galvanized steel.

3. Bearings: corrosion resistant, molded synthetic and axles shall positively lock into the damper blade.
4. Standoff: Factory installed 2" hand quadrant stand-off bracket.
5. Model: Equal to Ruskin MDRS25

E. Conical Manual Volume Damper Takeoffs:

1. All take-offs to air distribution devices shall be 26-ga steel conical fitting with a 1" flange spun from the body of the fitting with adhesive gasket-spin-ins are not allowed. All conical taps will have a damper that includes a 2" stand-off bracket with a high quality locking quadrant, a 3/8" aluminum continuous rod with (2) U-bolts connecting the damper to the rod and nylon end bearings where the roof penetrates the spin collar barrel. Manufacturer to provide test data to indicate leakage is less than 1 cfm at 4" wg. Testing to be in accordance with ASHRAE Std 126-2008. Takeoffs to be equal to Flexmaster CBD-SOG-BO3.

F. Install flagging tape at all volume dampers.

2.5 FLEXIBLE DUCT CONNECTIONS

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated on Drawings.
- B. Connector: Fabric crimped into metal edging strip.
 1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric conforming to NFPA 90A, minimum density 30 oz per sq yd.
 2. Net Fabric Width: Approximately 6 inches wide.
 3. Metal: 3 inch wide, galvanized steel.
- C. Lead vinyl Sheet: Minimum 0.55 inch thick, 0.87 lbs. per sq ft, 10 dB attenuation in 10 to 10,000 Hz range.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers:
 1. Ruskin
 2. Greenheck
- B. Fabricate in accordance with NFPA 90A, UL 555, and UL 555S.
- C. Fire Resistance: 1-1/2 hours.
- D. Leakage Rating: Class I, maximum of 8 at 4 inches wg differential pressure.
- E. Damper Temperature Rating: 250 degrees F.
- F. Frame: 16 gage galvanized steel.
- G. Blades:
 1. Style: Airfoil-shaped, single piece, double skin
 2. Action: Opposed
 3. Orientation: Horizontal
 4. Material: Minimum 16 gage equivalent thickness, galvanized steel.
 5. Width: Maximum 6 inches.
- H. Bearings: Stainless steel pressed into frame.

- I. Seals: Silicone blade edge seals and flexible stainless steel jamb seals.
- J. Linkage: Concealed in frame.
- K. Release Device: Close in controlled manner and lock damper through actuator closure spring.
- L. Actuator:
 - 1. Type: Electric 120V - 1PH, two-position, fail close.
 - 2. Mounting: External.
- M. Fusible Link Release Temperature: 165 degrees F.
- N. Finish: Mill galvanized.
- O. Factory installed sleeve and mounting angles. Furnish silicone caulk factory applied to sleeve at damper frame to comply with leakage rating requirements.

2.7 SMOKE DAMPERS

- A. Manufacturers:
 - 1. Ruskin
 - 2. Greenheck
- B. Fabricate in accordance with NFPA 90A and UL 555S.
- C. Fire Resistance: 1-1/2 hours.
- D. Leakage Rating: Class I, maximum of 8 cfm at 4 inches wg differential pressure.
- E. Damper Temperature Rating: 250 degrees F.
- F. Frame: 16 gage, galvanized steel.
- G. Blades:
 - 1. Style: Airfoil-shaped, single piece, double skin.
 - 2. Action: Opposed.
 - 3. Orientation: Horizontal.
 - 4. Material: Minimum 16 gage equivalent thickness, galvanized steel.
 - 5. Width: Maximum 6 inches.
- H. Bearings: Stainless steel pressed into frame.
- I. Seals: Silicone blade edge seals and flexible stainless steel jamb seals.
- J. Linkage: Concealed in frame.
- K. Actuator:
 - 1. Type: Electric 120V - 1 PH, two-position, fail close.
 - 2. Mounting: External.
- L. Sleeve: Factory installed 20 gage sleeve, minimum 12 inches long.
- M. Finish: Mill galvanized.

2.8 SOUND ATTENUATORS

- A. Duct silencers, with testing-verified performance, can attenuate sound better than many duct design features where performance is only approximated. See Evaluations.
 - 1. Kinetics
 - 2. Vibro-Acoustics
 - 3. Price Industries
- B. General Requirements:
 - 1. Attenuators shall be of the size, configuration, capacity and acoustic performance as scheduled on the drawings. All attenuators shall be factory fabricated and supplied by the same manufacturer.
 - 2. Attenuator inlet and outlet connection dimensions must be equal to the duct sizes shown on the drawings. Duct transitions at attenuators are not permitted unless shown on the contract drawings.
 - 3. Attenuators 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 other sections are minimums. Material gauges shall be increased as required for the system pressure and velocity classification. The attenuators shall not fail structurally when subjected to a differential air pressure of 8 inches water gauge.
 - 4. All casing seams and joints shall be lock-formed and sealed or stitch welded and sealed except as noted in Section G below, 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.
 - 5. All perforated steel shall be adequately stiffened to insure flatness and form. All spot welds shall be painted.
 - 6. Fire-Performance Characteristics: Attenuator assemblies, including acoustic media fill, Vibar™ film liner, sealants, and acoustical spacer, shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84, NFPA 255 or UL 723.
 - 7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.
- C. Rectangular Attenuators: Outer casing shall be ASTM A 653/A 653M, G90 galvanized sheet steel, 22 gauge.
- D. Rectangular Elbow Attenuators: Outer casing shall be ASTM A 653/A 653M, G90 galvanized sheet steel, 18 gauge. 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 attenuators with a turning cross-section dimension greater than 48" shall have at least two half splitters and one full splitter.

- E. Circular Attenuators: Outer casing shall be ASTM A 653/A 653M, G90 galvanized sheet steel, gauge as listed below.
 - 1. Sheet metal thickness for units up to 18 Inches in Diameter: 22 gauge.
 - 2. Sheet metal thickness for units 18 through 30 Inches in Diameter: 20 gauge.
 - 3. Sheet metal thickness for units 30 through 54 Inches in Diameter: 18 gauge.
 - 4. Sheet metal thickness for units over 54 Inches in Diameter: 16 gauge.
- F. Transitional Attenuators: Outer casing shall be ASTM A 653/A 653M, G90 galvanized sheet steel, 22 gauge. Transitioning shall occur internal to the attenuator such that the height of the gap or air passage is uniformly changing with the length of the splitters.
- G. Inner perforated metal liner: ASTM A 653/A 653M, G90 galvanized sheet steel.
 - 1. Rectangular Attenuators: 26 gauge.
 - 2. Rectangular Elbow Attenuators: 22 gauge.
 - 3. Circular Attenuators:
 - a. Connection diameter up to 18 inches: 26 gauge.
 - b. Connection diameter greater than 18 inches: 22 gauge.
 - 4. Transitional Attenuators: 22 gauge.
- H. Principal Sound-Absorbing Mechanism:
 - 1. No-Media Attenuators:
 - a. Shall not contain absorptive media of any kind. Attenuation shall be achieved with controlled impedance membranes and broadly tuned resonators.
 - 2. Dissipative and Film Lined Attenuators:
 - a. 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 attenuator assembly. Media shall be resilient such that

it will not crumble or break, and conform 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.

I. Media Protection:

1. Film Lined Attenuators: The acoustic media shall be completely wrapped with Vibar™ film to help prevent shedding, erosion and impregnation. The wrapped acoustic media shall be separated from the perforated metal by a factory installed ½" thick acoustically transparent spacer. The spacer shall be flame retardant and erosion resistant. A mesh, screen or corrugated perforated liner will not be acceptable as a substitute for the specified spacer. Attenuator manufacturer shall provide a written test report by a third party organization showing attenuator assemblies have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84, NFPA 255 or UL 723.

- J. HTL Casings: Where indicated on the attenuators schedule, attenuators shall have high transmission loss (HTL) walls externally applied and completely sealed to the attenuator casing by the attenuator 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 attenuator submittal to insure compliance with the room noise criteria. Breakout noise calculations shall be based on the sound power levels of the specified equipment.

K. Special Construction:

1. Where noted on the attenuator schedule, attenuators shall have 16 gauge casing, continuously welded.
2. Where indicated on the attenuator schedule, attenuators shall have RF filters integral to the attenuator. Performance shall be 100 dB at 1 MHz. Pressure drop shall be included in overall attenuator pressure drop. RF filter shall be located such that it cannot be bypassed.
3. Where indicated on the attenuator schedule, provide a non-conductive section in the attenuator casing at the end of the attenuator next to the room wall, and provide a minimum of 10" x 10" inspection port

in the attenuator casing next to the wall. These features shall not compromise the composite HTL casing of the attenuator.

4. Where indicated on the attenuator schedule, provide security bars running at 6" centers both ways inside the attenuator casing to prevent ingress through the attenuator.

L. Accessories:

1. Access Doors: Where indicated on the attenuator schedule, attenuators shall be supplied with an access door(s) to permit fire damper service. Access doors shall be supplied as an integral part of the attenuator by the attenuator manufacturer. Where HTL walls are also supplied, the access doors shall not reduce the effectiveness of the HTL walls.
2. Shipping Protection: Attenuators shall be shipped with factory-installed end caps to prevent contamination during shipping.
3. Airflow Measuring Devices: Where indicated on the attenuator schedule, attenuators shall have airflow measuring devices factory installed as part of the attenuator assembly.

M. Source Quality Control: Test according to ASTM E 477-06a.

1. The manufacturer shall test the attenuator(s) as indicated in the attenuator schedule. The engineer shall be notified of the test date at least two weeks in advance and the test may be witnessed by the engineer. Test shall show compliance with the project criteria and is subject to engineer approval.
2. Test facilities and test reports shall be open to inspection upon request from the Engineer. Attenuator performance must have been substantiated by laboratory testing according to ASTM E-477-06a and so certified when submitted for approval. The aero-acoustic laboratory must be NVLAP accredited for the ASTM E-477-06a test standard. A copy of the accreditation certificate must be included with the submittals. Data from non-NVLAP accredited test facilities will not be accepted.

N. Capacities and Characteristics:

1. See duct attenuator performance schedule on drawings.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Coordination and project conditions. As specified in Division 1.
- B. Verify rated walls are ready for fire damper installation.
- C. Verify ducts and equipment installations are ready for accessories.

- D. Check location of air outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

3.2 INSTALLATION

- A. Install in accordance with NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 23 31 00 for duct construction and pressure class.
- B. Access Doors: Install access doors at the following locations and as indicated on Drawings:
 - 1. Upstream of each reheat coil.
 - 2. Before or after each duct mounted coil.
 - 3. Before or after each duct mounted fan.
 - 4. Before or after each automatic control damper.
 - 5. Before or after each fire damper, smoke damper and combination fire and smoke damper to allow ease of access to reset damper.
- C. Install fire dampers, combination fire and smoke dampers and smoke dampers at locations as indicated on Drawings. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
 - 1. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92A.
 - 2. Install dampers square and free from racking with blades running horizontally.
 - 3. Do not compress or stretch damper frame into duct or opening.
 - 4. Handle damper using sleeve or frame. Do not lift damper using blades, actuator, or jack shaft.
 - 5. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

3.3 DEMONSTRATION

- A. Requirements for demonstration and training. As specified in Division 1.
- B. Demonstrate re-setting of fire dampers to Owner's representative.

- - - END - - -

SECTION 23 34 00
HVAC FANS

PART 1 GENERAL

1.1 DESCRIPTION

- A. Fans for heating, ventilating and air conditioning.
- B. Product Definitions: AMCA Publication 99, Standard 1-66.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- E. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- F. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- H. Section 23 74 13, CUSTOM CENTRAL STATION AIR HANDLING UNITS.

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Fans and power ventilators shall be listed in the current edition of AMCA 261, and shall bear the AMCA performance seal.
- C. Operating Limits for Centrifugal Fans: AMCA 99 (Class I, II, and III).
- D. Fans and power ventilators shall comply with the following standards:
 - 1. Testing and Rating: AMCA 210.
 - 2. Sound Rating: AMCA 300.
- E. Vibration Tolerance for Fans and Power Ventilators: Division 23.
- G. Safety Criteria: Provide manufacturer's standard screen on fan inlet and discharge where exposed to operating and maintenance personnel.
- H. Corrosion Protection:
 - 1. Except as specified for isolation room exhaust fans, all steel shall be mill-galvanized, or phosphatized and coated with minimum two coats, corrosion resistant enamel paint. Manufacturers paint and paint system shall meet the minimum specifications of: ASTM D1735 water fog; ASTM B117 salt spray; ASTM D3359 adhesion; and ASTM G152 and G153 for carbon arc light apparatus for exposure of non-metallic material.
- I. Spark resistant construction: If flammable gas, vapor or combustible dust is present in concentrations above 20% of the Lower Explosive Limit (LEL), the fan construction shall be as recommended by AMCA's

Classification for Spark Resistant Construction. Drive set shall be comprised of non-static belts for use in an explosive.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturers Literature and Data:
 - 1. Fan sections, motors and drives.
 - 2. Centrifugal fans, motors, drives, accessories and coatings.
 - 3. Prefabricated roof curbs.
- C. Certified Sound power levels for each fan.
- D. Motor ratings types, electrical characteristics and accessories.
- E. Belt guards.
- F. Maintenance and Operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
- G. Certified fan performance curves for each fan showing cubic feet per minute (CFM) versus static pressure, efficiency, and horsepower for design point of operation.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Movement and Control Association International, Inc. (AMCA):
 - 99-86.....Standards Handbook
 - 210-06.....Laboratory Methods of Testing Fans for
Aerodynamic Performance Rating
 - 261-09.....Directory of Products Licensed to bear the AMCA
Certified Ratings Seal - Published Annually
 - 300-08.....Reverberant Room Method for Sound Testing of
Fans
- C. American Society for Testing and Materials (ASTM):
 - B117-07a.....Standard Practice for Operating Salt Spray (Fog)
Apparatus
 - D1735-08.....Standard Practice for Testing Water Resistance
of Coatings Using Water Fog Apparatus
 - D3359-08.....Standard Test Methods for Measuring Adhesion by
Tape Test
 - G152-06.....Standard Practice for Operating Open Flame
Carbon Arc Light Apparatus for Exposure of Non-
Metallic Materials

G153-04.....Standard Practice for Operating Enclosed Carbon
Arc Light Apparatus for Exposure of Non-Metallic
Materials

D. National Fire Protection Association (NFPA):

NFPA 96-08.....Standard for Ventilation Control and Fire
Protection of Commercial Cooking Operations

E. Underwriters Laboratories, Inc. (UL):

181-2005.....Factory Made Air Ducts and Air Connectors

1.6 EXTRA MATERIALS

A. Provide one additional set of belts for all belt-driven fans.

PART 2 PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide
products by one of the following:

1. Greenheck Fan Corporation
2. Loren Cook Company.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square,
one-piece, aluminum base with venturi inlet cone.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection
mounted inside fan housing, factory wired through an internal
aluminum conduit.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted
in curb base; factory set to close when fan stops.

E. Electronically Commutated Motors

1. Motor enclosures: Open type.
2. Motor to be a DC electronic commutation type motor (ECM) specifically
designed for fan applications. AC induction type motors are not
acceptable. Examples of unacceptable motors are: Shaded Pole,
Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3
phase induction type motors.
3. Motors are permanently lubricated, heavy duty ball bearing type to
match with the fan load and pre-wired to the specific voltage and
phase.
4. Internal motor circuitry to convert AC power supplied to the fan to
DC power to operate the motor.
5. Motor shall be speed controllable down to 20% of full speed (80%
turndown). Speed shall be controlled by either a potentiometer dial
mounted at the motor or by a 0-10 VDC signal.

6. Motor shall be a minimum of 85% efficient at all speeds.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange.

2. Coordinate curb height with roof deck construction and insulation thickness; other heights are available. 16-inch (400-mm) height in first subparagraph below is for sound curb.

3. Subparagraphs below are optional features.

4. Sound Curb: Curb with sound-absorbing insulation.

5. Pitch Mounting: Manufacture curb for roof slope.

6. Metal Liner: Galvanized steel.

2.3 HIGH PLUME BLOWER - LAB EXHAUST

A. Manufacturers:

1. Greenheck

2. Loren Cook

B. Base fan performance at standard conditions (density 0.075 Lb./ft³).

C. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.

D. Each fan shall be belt driven.

E. Each fan to be equipped with 316 stainless steel lifting lugs for corrosion resistance.

F. Fasteners exposed to corrosive exhaust shall be stainless steel.

G. Fan assembly shall be designed for a minimum of 125 MPH wind loading, without the use of guy wires.

H. Corrosion Resistant Coating: All fan and system components (fan, nozzle, windband and plenum) shall be corrosion resistant coated with LabCoat, a two part electrostatically applied and baked, sustainable, corrosion resistant coating system. Standard finish color to be gray. All parts shall be cleaned and chemically prepared for coating using a multi-stage wash system which includes acid pickling that removes oxide, increases surface area, and improves coating bond to the substrate. The first powder coat applied over the prepared surface shall be a zinc rich epoxy primer (no less than 70% zinc) and heated to a gelatinous consistency (partial cure) at which the second powder coat of polyester resin shall be electrostatically applied and simultaneously be cured at a uniform temperature of 400°F. The coating system, a total thickness of up to 6 mils, is not affected by the UV component of sunlight (does not chalk), and has superior corrosion resistance to acid, alkali, and solvents. Coating system shall exceed 4000 hour ASTM B117 Salt Spray Resistance. Note that 10-20 mil thick wet coating systems pollute the

environment (air and water), and that these manually applied coatings are not uniform over the impeller surface and can cause fan imbalance and vibration.

I. Fan Housing and Outlet:

1. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
2. Fan housing shall be welded steel and meet specification section 2.15 for corrosion resistant coating. No uncoated metal fan parts shall be acceptable.
3. Fan housings that are fabricated of polypropylene or fiberglass that have lower mechanical properties than steel, have rough interior surfaces in which corrosive, hazardous compounds can collect, and / or which chalk and structurally degrade due to the UV component of the sunlight shall not be acceptable.
4. A high velocity conical discharge nozzle shall be supplied by the fan manufacturer and be designed to efficiently handle an outlet velocity of up to 6000 FPM. Discharge stack caps or hinged covers, impeding exhaust flow shall not be permitted.
5. Provide housing drain for removal of rain and condensation.
6. A bolted and gasketed access door shall be supplied in the fan housing allowing for impeller inspection or removal of impeller, shaft and bearings without removal of the fan housing.

J. Fan Impeller:

1. Fan impeller shall be centrifugal, backward inclined, with non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically per AMCA Standard 204.
2. Fan impeller shall be manufactured of aluminum (AMCA type B spark resistant), fully welded and meet specification section 2.15 for corrosion resistant coating.

K. Fan Bypass Air Plenum:

1. For constant volume systems, the fan shall be connected directly to the exhaust duct without the need of a bypass air plenum. Fans mounted directly to roof curbs shall be provided with a damper tray located in the roof curb for mounting of the gravity isolation damper.
2. The plenum shall be constructed of fully welded steel, meet specification section 2.15 for corrosion resistant coating, and mount on roof curb as shown on the project drawings. Plenums that are fabricated of plastics or resins that are combustible and have mechanical properties less than steel shall not be acceptable.

3. The bypass air plenum shall be mounted on factory fabricated roof curb provided by the fan manufacturer, as shown on the project drawings (see section 2.5)
4. Fan designs that use inlet flexible connectors that can leak causing loss of lab exhaust shall not be accepted.
5. A fan isolation damper, either gravity backdraft or two position actuated, fabricated of steel or aluminum and coated with minimum 4 mils of Hi-Pro Polyester resin, electrostatically applied and baked, shall be provided as shown on the project documents.
6. Blower / Plenum vibration isolation shall be limited to neoprene / cork vibration pads.

L. Bypass Air Plenum Curb:

1. Exhaust system manufacturer shall supply a structural support curb for the plenum, of specified height, as shown on the drawings.
2. Curb shall be fabricated of a minimum of 14 gauge corrosion resistant coated steel and structurally reinforced. Seismic certification requires a minimum of 12 gauge corrosion resistant coated steel and structurally reinforced roof curb be provided.
3. Curbs shall be insulated.
4. When properly anchored to the roof structure, the standard curb / plenum / blower assembly shall withstand wind loads of up to 125 mph without additional structural support.

M. Fan Motors and Drive:

1. Motors shall be premium efficiency, standard NEMA frame, 1800 or 3600 RPM, TEFC with a 1.15 service factor. A factory-mounted NEMA 3R disconnect switch shall be provided for each fan. Motor maintenance shall be accomplished without fan impeller removal or requiring maintenance personnel to access the contaminated exhaust components.
2. Drive belts and sheaves shall be sized for 200% of the motor horsepower, and shall be readily and easily accessible for service, if required. Drive shall consist of a minimum of two belts under all circumstances.
3. Fan shaft to be turned and polished of 1040 steel material (optional 316 stainless steel) as standard, coated with corrosion resistant coating.
4. Fan shaft bearings shall be Air Handling Quality, ball or roller pillow block type and be sized for an L-10 life of no less than 100,000 hours. Bearings shall be fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability. Bearings that use set screws shall not be allowed.

5. All shaft bearings shall have extended lube lines with zerk fittings.

N. Upblast Centrifugal - Direct Drive

1. Roof exhaust fans shall be upblast centrifugal direct drive type.

The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.

2. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. Windbands shall have a rolled bead for added strength and shall be joined to curbcaps with a leakproof, continuously welded seam.

2.4 IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck Fan Corporation
2. Loren Cook Company.

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

D. Fan Wheels:

1. Aluminum, airfoil blades welded to aluminum hub.

E. Accessories:

1. See schedule for required accessories.

F. Electronically Commutated Motors:

1. Motor enclosures: Open type
2. Motor to be a DC electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors.
3. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
4. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor.
5. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.

6. Motor shall be a minimum of 85% efficient at all speeds.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install fan, motor and drive in accordance with manufacturer's instructions.
- B. Align fan and motor sheaves to allow belts to run true and straight.
- C. Bolt equipment to curbs with galvanized lag bolts.
- D. Install vibration control devices as shown on drawings and specified in Division 23.

3.2 PRE-OPERATION MAINTENANCE

- A. Lubricate bearings, pulleys, belts and other moving parts with manufacturer recommended lubricants.
- B. Rotate impeller by hand and check for shifting during shipment and check all bolts, collars, and other parts for tightness.
- C. Clean fan interiors to remove foreign material and construction dirt and dust.

3.3 START-UP AND INSTRUCTIONS

- A. Verify operation of motor, drive system and fan wheel according to the drawings and specifications.
- B. Check vibration and correct as necessary for air balance work.
- C. After air balancing is complete and permanent sheaves are in place perform necessary field mechanical balancing to meet vibration tolerance in Division 23.

- - - E N D - - -

SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

Air terminal units, air flow control valves.

1.2 RELATED WORK

- A. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic restraints for equipment.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- C. Section 23 31 00, HVAC DUCTS AND CASINGS: Ducts and flexible connectors.
- D. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Valve operators.
- E. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC: Flow rates adjusting and balancing.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Air Terminal Units: Submit test data.
 - 2. Air flow control valves.
- C. Certificates:
 - 1. Compliance with paragraph, QUALITY ASSURANCE.
 - 2. Compliance with specified standards.
- D. Operation and Maintenance Manuals: Submit in accordance with paragraph, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. Air Conditioning and Refrigeration Institute (AHRI)/(ARI):

880-08.....Air Terminals Addendum to ARI 888-98
incorporated into standard posted 15th December
2002

C. National Fire Protection Association (NFPA):

90A-09.....Standard for the Installation of Air
Conditioning and Ventilating Systems

D. Underwriters Laboratories, Inc. (UL):

181-08.....Standard for Factory-Made Air Ducts and Air
Connectors

E. American Society for Testing and Materials (ASTM):

C 665-06.....Standard Specification for Mineral-Fiber
Blanket Thermal Insulation for Light Frame
Construction and Manufactured Housing

1.6 GUARANTY

In accordance with the GENERAL CONDITIONS

PART 2 - PRODUCTS

2.1 GENERAL

A. Coils:

1. Water Heating Coils:

- a. ARI certified, continuous plate or spiral fin type, leak tested at 300 PSI.
- b. Capacity: As indicated, based on scheduled entering water temperature.
- c. Headers: Copper or Brass.
- d. Fins: Aluminum, maximum 8 fins per inch.
- e. Tubes: Copper, arrange for counter-flow of heating water.
- f. Provide vent and drain connection at high and low point, respectively of each coil.
- g. Coils shall be guaranteed to drain.

B. Labeling: Control box shall be clearly marked with an identification label that lists such information as nominal CFM, maximum and minimum factory-set airflow limits, coil type and coil connection orientation, where applicable.

C. Factory calibrate air terminal units to air flow rate indicated. All settings including maximum and minimum air flow shall be field adjustable.

2.2 AIR TERMINAL UNITS (VAV BOXES)

- A. Manufacturers:
 - 1. E. H. Price
 - 2. Titus
- B. General: Factory built, pressure independent units, factory set-field adjustable air flow rate, suitable for single duct applications. Clearly show on each unit the unit number and factory set air volumes corresponding to the contract drawings. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC work assumes factory set air volumes. Coordinate flow controller sequence and damper operation details with the drawings and Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- C. Sound Power Levels: Acoustic performance of the air terminal units shall be based on the design noise levels for the spaces stipulated in Section 23 05 41 (Noise and Vibration Control for HVAC Piping and Equipment). Max NC for each VAV box to be 30.
- D. Casing: Unit casing shall be constructed of 22 gage galvanized steel. All boxes to be double-wall construction. Insulation to be 1/2-in. thick and 1.5 lb. / cu. ft. density. Provide hanger brackets for attachment of supports. Inlet to be round stub connection, and outlet to be S-drive connection.
 - 1. Factory-installed access panels (or doors): Provide panels large enough for inspection, adjustment and maintenance without disconnecting ducts, and for cleaning heating coils attached to unit, bottom mounted. Panels shall be insulated to same standards as the rest of the casing and shall be secured and gasketed airtight. It shall require no tool to remove.
 - 2. Total leakage from casing: Not to exceed 2 percent of the nominal capacity of the unit when subjected to a static pressure of 3 inch WG, with all outlets sealed shut and inlets fully open.
- E. Construct damper of galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Damper Leakage: Not greater than 2 percent of maximum rated capacity, when closed against inlet static pressure of 4 inch WG.
- F. Provide multi-point velocity pressure sensors with external pressure taps.
 - 1. Provide direct reading air flow rate table pasted to box.
- G. Provide static pressure tubes.

- H. Externally powered DDC variable air volume controller and damper actuator to be furnished under Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC for field mounting on air terminal units. The DDC controller shall be electrically actuated.
- I. Provide with disconnect and transformer for required control voltage output.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.
- B. Handle and install units in accordance with manufacturer's written instructions.
- C. Support units rigidly so they remain stationary at all times. Cross-bracing or other means of stiffening shall be provided as necessary. Method of support shall be such that distortion and malfunction of units cannot occur.
- D. Locate air terminal units to provide a straight section of inlet duct for proper functioning of volume controls. See Details.
- E. Where coil connection kits with flexible connectors are utilized, connections are to be installed such that strainer and drain are level or below the bottom of the coil.

3.2 OPERATIONAL TEST

Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

- - - E N D - - -

SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Diffusers.
 - 2. Registers
 - 3. Grilles.

1.2 REFERENCES

- A. Air Movement and Control Association International, Inc.:
 - 1. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:
 - 1. ASHRAE 70 - Method of Testing for Rating the Performance of Air Outlets and Inlets.
- C. Sheet Metal and Air Conditioning Contractors:
 - 1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

1.3 SUBMITTALS

- A. Shop Drawings, Product Data, and Samples as specified in Division 1.
- B. Product Data: Submit sizes, finish, and type of mounting. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.
- C. Test Reports: Rating of air outlet and inlet performance.

1.4 CLOSEOUT SUBMITTALS

- A. Contract Closeout as specified in Division 1.
- B. Project Record Documents: Record actual locations of air outlets and inlets.

1.5 QUALITY ASSURANCE

- A. Test and rate diffuser, register, and grille performance in accordance with ASHRAE 70.

1.6 WARRANTY

- A. Contract Closeout as specified in Division 1.
- B. Furnish one year manufacturer warranty for air outlets and inlets.

PART 2 PRODUCTS

2.1 RECTANGULAR CEILING DIFFUSERS

- A. Manufacturers:
 - 1. E. H Price Company
 - 2. Titus
- B. Type: Square, louvered diffuser to discharge air in four-way pattern or as indicated on Drawings.
- C. Frame: Surface mount or Inverted T-bar type. In hard ceilings, furnish plaster frame and trim.
- D. Fabrication: Steel with baked enamel off-white finish.
- E. Accessories: Damper with damper adjustable from diffuser face, (where indicated). Provide all diffusers with factory insulated backpan.

2.2 CEILING CUBE CORE EXHAUST AND RETURN GRILLES

- A. Manufacturers:
 - 1. E. H Price Company
 - 2. Titus
- B. Type: Fixed grilles of $\frac{1}{2}$ X $\frac{1}{2}$ X 1 inch openings. Sight-proof design.
- C. Fabrication: Aluminum with factory off-white enamel finish.
- D. Frame: 1 inch margin with channel lay-in frame for suspended grid ceilings. Furnish plaster frame and trim for installation in hard ceiling.
- E. Provide opposed blade damper, square-round adapter, and metal filler panel where indicated on Drawings.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Coordination as specified in Division 1.
- B. Verify inlet and outlet locations.
- C. Verify ceiling wall systems are ready for installation.

3.2 INSTALLATION

- A. Install diffusers to ductwork with airtight connection.
- B. Install balancing dampers on duct take-off to diffusers, grilles, and registers, whether or not dampers are furnished as part of diffuser, grille, and register assembly.

3.3 INTERFACE WITH OTHER PRODUCTS

- A. Check location of outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

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SECTION 23 40 00
HVAC AIR FILTERS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Disposable panel filters.
 - 2. High efficiency particulate air (HEPA) filters.
 - 3. Filter frames and housings.
 - 4. Filter gages.

1.2 REFERENCES (latest edition for each)

- A. ARI 850
- B. ASHRAE 52.1
- C. ASHRAE 52.2
- D. UL 586
- E. UL 900
- F. NFPA 90A

1.3 SUBMITTALS

- A. Section 01 33 23 - Shop Drawings, Product Data and Samples.
- B. Product Data: Submit data on filter media, filter performance data, and dimensions.
- C. Manufacturer's Installation Instructions: Submit assembly and change-out procedures.

1.4 EXTRA MATERIALS

- A. Furnish one set of pre-filters and one set of HEPA final-filters per filter housing. Furnish one set of HEPA filter removal bags per each housing.

PART 2 PRODUCTS

2.1 DISPOSABLE PANEL FILTERS

- A. Manufacturers:
 - 1. Viledon
 - 2. No substitutions
- B. 2" thick, UL 900 Class 2, extended surface filter. 30% dust spot efficiency per ASHRAE 52.1. MERV 8 per ASHRAE 52.2. Performance per ARI 850. Constructed of reinforced, non-woven cotton/synthetic blend media laminated to an expanded metal grid on the air leaving side and formed into radial wedge pleats.

- C. Holding Frames: Frame shall be moisture-resistant carrier board with diagonal and horizontal support members on the upstream and downstream sides, and shall have locking corners.

2.2 HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTERS

- A. Manufacturers:
 - 1. Viledon
 - 2. No substitutions
- B. Separator filter packs shall be constructed by pleating a continuous sheet of non-woven water-resistant fiberglass media around hemmed-edge corrugated aluminum separators. Separatorless-type filter pack shall be constructed by pleating a continuous sheet of formed, corrugated medium so that the pack is self-supporting without the use of spaces of any kind, including separators, tape strings, adhesives or strips of media.
- C. The filter pack shall be sealed into a 14 gauge Type 409 Stainless Steel frame with urethane sealant.
- D. A silicone gel in a channel shall be provided on the side to seal the filter in the housing.
- E. Filters to have a minimum efficiency of 99.97% on 0.30 micrometer particles when tested at rated capacity on a Q-107 Penetrometer.

2.3 FILTER FRAMES AND HOUSINGS (HEPA FILTER ASSEMBLY)

- A. Manufacturers:
 - 1. Camfil Farr
 - 2. Flanders
 - 3. AAF International
- B. Housings: Filter housing to be 14 gage Type 304 stainless steel, bag-in/bag-out, with side access design. The housing shall be adequately reinforced to withstand a negative or positive pressure of 10 in wg. Housing to be a gel seal design which incorporates a knife edge that mates into the gel filled perimeter channel of the face on the filter. All pressure retaining weld joints and seams shall be continuously welded with no pores allowed. All hardware on the housing and all mechanical components of the filter sealing mechanism shall be Type 300 series stainless steel, except for the cast aluminum access door knobs.
- C. Bagging: The housing shall have a bagging ring around each filter access port. The bagging ring shall have two (2) continuous ribs to secure the PVC change-out bag. The outer edge of the ring shall be hemmed to prevent the bag from tearing. Each access port and bagging ring shall be covered by a door having an extruded neoprene gasket that is manually replaceable after the door has been removed. When closed, the door shall not press against the bag-out port and PVC bag, thus eliminating the possibility of damage to the bag.
- D. Bags: One (1) PVC change-out bag shall be furnished for each filter access port. Each bag shall have its stock number rolled in the hem. The PVC bag material shall be 8-mil thick, yellow in color, with a

translucent taffeta texture finish and shall not stick together. The bag shall include approximately 16 inches of clear PVC at the mouth. Three (3) glove sleeves shall be built into the bag to facilitate handling the filter during change-out. PVC bags shall be tested by an independent laboratory to prove the bag's operability at temperature ranges of 0 deg F to 130 deg F.

- E. The filter housing shall meet the requirements of ASME NQA-1. The housing shall be tested for filter fit, operation of the filter clamping mechanism, knife edge alignment and leak tightness before leaving the factory. Both the filter sealing surface and the complete assembly pressure boundary shall be leak tested by the "Pressure Decay Method," in accordance with ASME N510-1995 "Reaffirmed," "Testing of Air Cleaning Systems," paragraphs 6 and 7. There shall be a maximum leak rate of 0.0005 CFM per cubic foot of housing volume at 10 in wg.
- F. Door Latches: Standard Latches are threaded studs with removable knobs. The studs align with the retainers provided at each corner of the door and are secured with hand knobs.

2.4 95% BAG TYPE FILTERS

- A. Manufacturers:
 - 1. Viledon
 - 2. No substitutions.
- B. Filters shall be constructed of lofted fiberglass or micro-fine synthetic media encased in a thin non-woven polyester backer mat. Filters up to 22 inches in depth shall be designed to operate in Variable Air Volume Systems. Open area on the filter face for air passage shall be not less than 90%.
- C. Flexible internal support stitching shall maintain individual pockets in a controlled form under all rated air flow conditions. Stitching shall be sealed with thermoplastic sealant. Edges shall be finished with over lock stitch to prevent air unraveling. Provide the cartridge frame with a gasket on the vertical sides to prevent leakage between the cartridges if installed in framing modules or side access housings.
- D. Pockets shall be 100% stake-through crimped to prevent media pullout. Pockets shall be bonded to corrosion-resistant steel casings and assembled into a corrosion-resistant steel header. Filters shall be UL 900 Class 2 construction and so listed.
- E. Initial and final resistances shall not exceed the scheduled values. Media area must equal or exceed that of the specified filter. The average efficiency shall be 95% as determined by the ASHRAE Standard 52.1 and 52.2 test methods. The manufacturer shall guarantee performance as stated in its literature within tolerances as outlined in Section 7.4 of ARI Standard 850.

2.5 MAGNEHELIC FILTER GAGES

- A. Manufacturers:
 - 1. Dwyer or equal.

- B. Direct Reading Dial: 3-1/2 inch diameter diaphragm actuated dial in metal case. Furnish vent valves, black figures on white background, front calibration adjustment, range 0-1.0 in wg (pre-filter) and 0-3.0 in wg (final or HEPA), 2 percent of full scale accuracy.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Where gages are required, install filter gage static pressure tips upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum, in accessible position. Adjust and level.
- B. Do not operate fan system until permanent filters are in place. Replace filters used during construction and testing, with clean set prior to TAB work and, if necessary, before Owner acceptance.

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SECTION 23 64 00
AIR-COOLED CHILLERS

PART 1 GENERAL

1.1 REFERENCES

- A. AHRI 550/590
- B. ASHRAE 90.1 - 2010
- C. ASHRAE 15-2004
- D. ASME Section VIII - Boiler and Pressure Vessel Code
- E. NEMA 250

1.2 RELATED WORK

- A. Section 00 72 00, GENERAL CONDITIONS.
- B. Section 01 00 00, GENERAL REQUIREMENTS.
- C. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- F. Section 23 21 23, HYDRONIC PUMPS.
- G. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- H. Section 23 21 13, HYDRONIC PIPING.
- I. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS
- J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 SUBMITTALS

- A. As specified in Division 1.
- B. Shop Drawings: Indicate components, assembly, dimensions, weights and loads, required clearances, and location and size of field connections.
- C. Product Data: Submit rated capacities, AHRI performance data, weights, specialties and accessories, electrical requirements, wiring diagrams, and control diagrams.
- D. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include startup instructions.
- E. Manufacturer's Field Reports: Submit start-up report for each unit.

1.4 CLOSEOUT SUBMITTALS

- A. As specified in Division 1.
- B. Operation and Maintenance Data: Submit start-up instructions, maintenance data, parts lists, controls, and accessories. Include trouble-shooting guide.

1.5 QUALITY ASSURANCE

- A. Conform to AHRI 550/590 code for testing and rating of air-cooled chillers.
- B. Performance Ratings: EER and IPLV as scheduled.

1.6 WARRANTY

- A. Provide a five-year complete unit warranty to include materials, parts, and labor.

PART 2 - PRODUCTS

2.1 AIR-COOLED CHILLERS

- A. Subject to spec and schedule requirements, provide products by one of the following manufacturers:
 - 1. McQuay
 - 2. Trane
 - 3. York
- B. Product Description: Factory assembled and tested, packaged, air-cooled chillers consisting of rotary screw compressors, compressor motor, condenser, evaporator, refrigeration accessories, instrument and control panel including gages and indicating lights, auxiliary components and accessories, and motor starters. Chiller shall be rated and certified according to AHRII 550/590.

2.2 SCREW COMPRESSORS

- A. Unit: Direct drive, semi-hermetic, rotary screw compressor with control panel.
- B. Features: Differential refrigerant pressure oil pump, oil heater, oil separator and filter and oil charging valve.
- C. Motor: Suction gas-cooled, hermetically sealed, squirrel cage induction.
- D. Automatic Capacity Reduction: Continuously variable slide valve with infinitely variable control to 25 percent of full load.
- E. Provide acoustical package to meet the sound performance scheduled. Provide sound pressure data per AHRI 370 for all eight octave bands at full load.
- F. Provide suction service shutoff valve for each compressor.

2.3 SCROLL COMPRESSORS

- A. Compressor Three dimensional, positive-displacement, hermetically sealed design, with suction and discharge valves, crankcase oil heater and suction strainer.
- B. Compressor shall be mounted on vibration isolators. Rotating parts shall be factory balanced.
- C. Lubrication system shall consist of reversible, positive displacement pump, strainer, oil level sight glass, and oil charging valve.
- D. Capacity control shall be by on-off compressor cycling of single and multiple compressors and hot gas bypass.

- E. Provide acoustical package to meet the sound performance scheduled.
Provide sound pressure data per AHRI 370 for all eight octave bands at full load.
- F. Provide suction service shutoff valve for each compressor.

2.4 EVAPORATOR

- A. Seamless or welded steel shell, seamless copper tubes, tubes with integral fins, rolled or silver brazed into tube sheets.
- B. Design, inspect, and stamp as per ASME Section VIII Requirements.
- C. Insulate with 0.75 inch minimum thick elastomeric insulation with maximum K factor of 0.28.
- D. Furnish water drain connection and thermometer wells for temperature controller and low temperature cutout.

2.5 CONDENSER COILS, FANS AND MOTORS

- A. Coils: Aluminum fins mechanically bonded to seamless copper tubing. Working pressure of 650 psig. Replace refrigerant charge lost during the warranty period, due to equipment failure, without cost to the Government.
- B. Louvered coil guards.
- C. Vertical direct driven propeller type condenser fans with fan guard on discharge, equipped with roller or ball bearings with grease fittings extended to outside of casing.
- D. Weatherproof motors suitable for outdoor use, 3 phase, with permanent lubricated ball bearings and built-in thermal overload protection.

2.6 REFRIGERANT CIRCUIT

- A. Factory furnished and piped with full oil and refrigerant charges.
- B. Furnish for each refrigerant circuit:
 - 1. Liquid line solenoid valve.
 - 2. Filter dryer (replaceable core type).
 - 3. Liquid line sight glass and moisture indicator.
 - 4. Thermal expansion for maximum operating pressure.
 - 5. Charging valve.
 - 6. Insulated suction line.
 - 7. Discharge line check valve.
 - 8. Compressor discharge service valve.
 - 9. Pressure relief device.

2.7 COMPRESSOR VARIABLE FREQUENCY DRIVE (VFD)

- A. Each compressor shall be equipped with a VFD providing compressor speed control as a function of the cooling load. Each VFD shall provide

controlled motor acceleration and deceleration, and shall provide protection for the following conditions:

1. Electronic thermal overload
 2. Over/under current,
 3. Stalled motor
 4. Input and output phase loss
 5. High load current and current unbalance.
- B. The VFD shall provide a minimum 91% unit power factor at all load points. The drive shall be equipped with DC reactors. Compressor used in VFD controlled units must have electrically insulated, coated bearing to mitigate bearing and/or lubricant damage from stray electric current passage. Units without this protection must have an extended 5-year compressor warranty
- C. The unit shall be equipped with factory-installed EMI filters and ground fault protection.

2.8 CONTROLS

- A. On or near chiller, mount control panel with NEMA Type 3R enclosure, containing starters, power and control wiring, factory wired with single point power connection.
- B. Furnish devices on control panel face:
1. Compressor, run lights.
 2. System start-stop switch.
 3. Control power fuse of circuit breaker.
- C. Furnish safety controls arranged so machine is shut down and requires manual reset:
1. Low chilled water temperature switch.
 2. High discharge pressure switch.
 3. Low suction pressure switch.
 4. Oil pressure switch.
 5. Flow switch in chilled water line.
 6. Controls for operation down to 32degrees F ambient temperature.
 7. Thermostat to cycle fan motors in response to out-door ambient temperature.
 8. Head pressure switch to cycle fan motors in response to refrigerant condensing pressure.
 9. Electronic low ambient control consisting of mixing damper assembly, controlled to maintain constant refrigerant condensing pressure.
 10. Load limit thermostat to limit compressor loading on high return water temperature.

11. Three phase monitor to protect unit by stopping compressor on phase loss, phase reversal, phase imbalance, or under voltage.
12. Provide factory-installed disconnect mounted on chiller.
13. Provide BACNet communications interface card.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install chiller on concrete foundation minimum 6 inches wider than equipment base on each side.
- B. Install units on rubber in shear vibration isolation. Isolation to be selected per manufacturer's recommendations.
- C. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping and electrical to verify actual locations and sizes before chiller installation and other conditions that might affect chiller performance, maintenance, and operation. Equipment locations shown on drawings are approximate. Determine exact locations before proceeding with installation.

3.2 STARTUP

- A. Provide field startup services by a factory-trained, authorized technician.
- B. After complete installation startup checks, according to the manufacturers written instructions, do the following to demonstrate that the equipment operate and perform as intended.
 1. Check refrigerant charge is sufficient and chiller has been tested for refrigerant leak.
 2. Check bearing lubrication and oil levels.
 3. Verify proper motor rotation.
 4. Verify pumps associated with chillers are installed and operational.
 5. Verify thermometers and gages are installed.
 6. Operate chiller for run-in-period in accordance with the manufacturer's instruction and observe its performance.
 7. Check and record refrigerant pressure, water flow, water temperature, and power consumption of the chiller.
 8. Test and adjust all controls and safeties. Replace or correct all malfunctioning controls, safeties and equipment as soon as possible to avoid any delay in the use of the equipment.
 9. Prepare a written report outlining the results of tests and inspections, and submit per Division 1 requirements.

3.3 DEMONSTRATION AND TRAINING

- A. Demonstrate system operations and verify specified performance. Provide

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training for owner staff on operation and maintenance of chiller.

- - - END - - -

SECTION 23 74 13

CUSTOM CENTRAL STATION AIR HANDLING UNITS

PART 1 GENERAL

1.1 WORK INCLUDED

- A. Custom air handling units and components as shown, scheduled, and indicated on the Drawings.

1.2 RELATED SECTIONS

- A. The requirements of the General Conditions, Supplementary Conditions, Division 1, and Drawings apply to all Work herein.

1.3 RATING AND CERTIFICATION REQUIREMENTS

- A. AMCA 99 - Standard Handbook.
- B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
- C. AMCA 300 - Test Code for Sound Rating Air Moving Devices
- D. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices
- E. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters
- F. ANSI / AFBMA 9 - Load Ratings and Fatigue Life for Ball bearings
- G. ANSI/UL 900 - Test Performance of Air Filter Units
- H. AHRI 410 - Forced-Circulation Air Cooling and Air Heating Coils
- I. NFPA 90A - Installation of Air Conditioning and Ventilation Systems
- J. ASME Code section IX, AWS D1.1, D1.2, or D9.1.
- K. AMCA 611-95 - Methods of Testing Airflow Measurement Stations for Rating
- L. ASHRAE 52.2 2007
- M. ASHRAE 62.1 2010
- N. ASHRAE 90.1 2010

O. AHRI 260 - Sound Rating of Ducted Air Moving and Conditioning Equipment

1.4 QUALITY ASSURANCE

- A. Manufacturer shall have a minimum of 5 years of experience in designing, manufacturing, and servicing air-handling units.
- B. The design shown on the drawing is based upon products of the manufacturer scheduled. Alternate equipment manufacturers shall be acceptable if equipment meets the scheduled performance and dimensional requirements, and complies with these specifications. The intent of this specification requirement is to assure that the products are manufactured through a quality system and framework that will assure consistent quality in products delivered.
- C. If equipment is supplied by a manufacturer other than the manufacturer names as Basis of Design, then the Mechanical Contractor shall be responsible for coordinating with the General Contractor and all affected Subcontractors to ensure the specified performance is met and proper provisions are made for installation of the furnished unit. This coordination shall include, but not be limited to, the following:
 - 1. Structural supports for units
 - 2. Size and location of concrete bases/housekeeping pads
 - 3. Location of roof curb, unit supports and roof penetrations
 - 4. Ductwork sizes and connection locations
 - 5. Piping size and connection/header locations
 - 6. Interference with existing or planned ductwork, piping, and wiring
 - 7. Electrical power requirements and wire/conduit and overcurrent protection sizes
 - 8. Trap height requirements
- D. The Mechanical Contractor shall be responsible for all costs incurred by the General Contractor, Subcontractors, and Consultants to modify the building provisions to accommodate units furnished by a manufacturer other than the manufacturer named as basis of design.

1.5 SUBMITTALS

- A. Submit shop drawings and product data according to Division 1.
- B. Dimensioned arrangement drawings for each AHU including a plan and elevation view of the assembled unit with overall dimensions, support

locations, and weights. Drawings shall also indicate all electrical, piping, and ductwork requirements, including sizes, connection locations, and connection method recommendations. Each component of the unit shall be identified and shall include physical dimensions and material of construction.

- C. Panel-to-panel joint and corner details and panel-to-roof details, all showing Class "A" thermal breaks.
- D. All performance data, including capacities and airside and waterside pressure drops, for components. AMCA-certified fan curves shall be provided with specified operating point clearly plotted. AMCA-certified sound power level data for fan inlet and outlet at fan rated capacity shall be provided. Fan curves shall be provided for fans with the design operating points indicated. Data shall be corrected to actual operating conditions, temperatures, and altitudes.
- E. All performance ratings shall be corrected for altitude of operation.
- F. Submit product data for filter media, filter performance data, filter assembly, and filter frames.
- G. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- H. Submit manufacturer's installation instructions according to Division 1.

1.6 DELIVERY, STORAGE AND HANDLING

- A. All handling and storage procedures shall be per manufacturer's recommendations.
- B. Manufacturers shall comply with ASHRAE 62.1 - 2010, requiring that building materials be protected from rain and other sources of moisture by appropriate in-transit and on-site procedures.
- C. Equipment specified for indoor applications shall be required to provide a protective covering membrane for such equipment being shipped by truck, rail, or ship. The membrane shall be fully formed around the equipment exterior. The membrane shall cover the entire top, side and

end panel surface as to protect the product effectively during shipping and short term. Storing on job-site shall not require the unit(s) to be covered with a tarp as long as the covering membrane has not been removed or damaged. All size or shape equipment including electrical components, especially those not built with weatherproof enclosures, shall be effectively covered for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust, & corrosion during shipping cycle. Equipment shall remain clean and dry.

- D. Manufacturers of indoor units not having a protective membrane, fully formed around the equipment exterior, covering the entire top, side and end panel surface shall be required to ship equipment covered with a tarp, in crating or in an enclosed truck as is necessary to ensure product protection from sun fading, road salt/chemicals, rust, corrosion, moisture and dirt infiltration. Arrangements for short term and/or long term storage at the job site shall be required.
- E. All openings shall be sealed to protect against damage during shipping, storage, and handling.
- F. Safety warning labels shall be securely affixed and clearly visible.
- G. All loose-shipped items shall be packed, protected and secured with the air units.
- H. Pipe chases shall ship loose as indicated on the Drawings.
- I. Rain hoods shall ship attached to the unit or as indicated on the drawings.
- J. Motors shall be protected and inspected in accordance with the manufacturer's specific instructions regarding periods of long storage. Periodic rotation of the shaft is required during long storage periods. Provisions shall be made to ensure no water is allowed to collect and remain in the motor terminal box or any electrical junction box.

1.7 EXTRA STOCK

- A. Provide one spare set of each type filter provided for unit.
- B. Provide one set of spare belts for each belt driven fan.

1.8 WARRANTY

- A. As specified in Division 1.

1.9 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Division 1.
- B. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

PART 2 PRODUCTS

2.1 GENERAL DESCRIPTION

- A. Air Handling Unit (AHU) shall consist of a structural base, insulated casing, access doors, fans, motors, motor controls, coils, filters, dampers, controls, components, and accessories as shown on drawings, schedules, and included in this specification.
- B. Provide AHU to meet the specified levels of performance for scheduled and specified items including airflow, static pressure, cooling capacity, heating capacity, electrical characteristics, sound, casing leakage, panel deflection and casing thermal performance.
- C. Provide AHU with a Class "A" thermal break, defined as a thermal break that ensures no member on the exterior of the unit, including fasteners, has through metal contact with any member on the interior of the unit, including fasteners.
- D. Unit splits shall be provided based on project constraints. Lifting lugs shall be supplied on each side of a shipping split and at all unit corners to facilitate rigging and aid in joining shipping sections. Lifting lugs shall be suitable for rigging without requiring additional support frames.

2.2 UNIT PERFORMANCE

- A. The air-handling unit shall be specifically designed for use in an indoor or outdoor application, as indicated on the Drawings.
- B. Casing shall include removable panels where indicated on drawings for servicing of equipment without compromising the equipment integrity.

- C. Fasteners exposed to weatherization and/or a corrosive environment shall be constructed of stainless steel material.

D. Bases & Floors:

1. Base shall be constructed from welded structural aluminum channels around the perimeter and welded structural aluminum cross members. Formed steel channels are not acceptable. The maximum cross-member spacing shall be 24" on center with members located adequately to support fan, coils, and other large components. The height of each base channel shall be no less than the height indicated in the drawings. Each shipping section shall be provided with removable lifting lugs. Structural framework shall fully support the unit casing and all components during installation such that no section deflects more than $L/1000$ during rigging of that section, where L is defined as the distance between lifting lugs.
2. Floor shall be constructed from 1/8" aluminum safety tread plate surface. The floor surface shall be continuously welded with 2" turned up lip around the base perimeter and all floor penetrations. Caulk is not an acceptable sealing method for the floor. Floor drains shall be located in the floor to drain all sections. Floor drains shall be a minimum of 1.5" in diameter and shall be piped to the exterior of the unit base. Floor deflection shall not exceed $L/200$ under a point load of 200 pounds, where L is defined as the floor span. An aluminum liner shall be attached to the underside of the unit base and cross members, ensuring that the floor insulation is completely encapsulated.
3. Insulation that meets a minimum R-value of 25.9 shall be provided underneath the entire unit floor. Insulation shall completely fill the panel cavity in all directions so that no voids exist. Base assemblies shall comply with NFPA 90 A.
4. Safety grates that provide a walking surface shall be provided across all bottom air openings. Safety grates shall support a minimum 300-pound load. Safety grates shall be made of Type IWA welded rod with a cross flow pattern of 1.1875" x 4". Grating shall be galvanized steel construction for units with galvanized or painted steel floors and shall be aluminum construction for units with aluminum floors. Safety grates shall be removable to ensure adequate access to the ductwork below.

E. Walls:

1. Wall assemblies shall be double-wall construction with galvaneal steel solid exterior and galvanized steel interior. The entire unit shall have a solid wall liner on the interior. All spaces and joints of wall assemblies shall be completely sealed. Wall shall meet the casing deflection limits contained herein.
2. A Class "A" thermal break shall be provided throughout the entire wall assembly.
3. Insulation that meets a minimum R-value of 25.9 shall be provided throughout all unit wall assemblies. Insulation shall completely fill the panel cavity in all directions so that no voids exist and settling of insulation is prevented. Wall assemblies shall comply with NFPA 90 A.
4. Removable wall access panels shall be provided in coil sections for service removal of components. A Class "A" thermal break shall be provided throughout all removal wall access panels.

F. Caulk and/or exposed gasket tape shall be a closed cell material and exhibit zero microbial growth.

G. External surfaces of all outdoor unit casings shall be prepared and painted. Paint shall be able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 700 consecutive hours. Paint shall be AHU Manufacturer's standard color, unless otherwise indicated in the schedule and drawings.

H. Roofs:

1. Roof assemblies shall be double wall construction. Exterior roof panels and interior ceiling panels shall be of the same construction as the exterior and interior wall panels, respectively. Sections in units with perforated interior wall liners shall have perforated interior ceiling liners. For perforated liners, a triple-wall panel shall be provided. This triple-wall panel shall be constructed such that two layers of the panel are solid, with the afore-mentioned class of thermal break between them to isolate the supply air from contact with the outside panel. The third, inner liner shall be perforated. All spaces and joints of roof assemblies shall be completely sealed. In addition to meeting the casing deflection

- limits contained herein, roof deflection shall not exceed $L/200$ under a point load of 200 pounds, where L is defined as the roof panel span.
2. A Class "A" thermal break shall be provided throughout the entire roof assembly.
 3. Insulation that meets a minimum R-value of $25 \text{ hr.ft}^2 \text{ }^\circ\text{F/BTU}$ shall be provided throughout all roof assemblies. Insulation shall completely fill the panel cavity in all directions so that no voids exist. Roof assemblies shall comply with NFPA 90 A.
 4. The outdoor air-handling unit shall be supplied with a sloped roof to promote drainage of precipitation and prevent standing water. Roof construction design shall accommodate a minimum load of 30 lb/ft^2 . Roofs less than 12' wide shall be sloped to the non-door side of the unit; roofs 12' wide and wider shall be peaked in the center and sloped to both sides of the unit.
 - a. The roof shall have a minimum pitch of $1/4"$ per foot.
 - b. The roof shall overhang all side and end panels to prevent precipitation drainage from streaming down the unit wall panels.

2.3 DOORS

- A. Access doors shall be provided throughout units as indicated on the schedules and drawings. Access doors shall be double wall construction. Interior and exterior door panels shall be of the same construction as the interior and exterior wall panels, respectively.
- B. A Class "A" thermal break shall be provided on all door assemblies downstream of the cooling coil.
- C. Insulation that meets a minimum R-value of $25 \text{ hr.ft}^2 \text{ }^\circ\text{F/BTU}$ shall be provided throughout all door assemblies. Insulation shall completely fill the panel cavity in all directions so that no voids exist and settling of insulation is prevented. Door assemblies shall comply with NFPA 90 A.
- D. All doors shall be a minimum of 60" high if sufficient height is available, or the maximum height allowed by the unit height. All doors shall open against pressure to ensure an airtight seal and to prevent a safety hazard.

- E. All doors with access to moving parts shall have provisions for padlocking and meet UL 1995 mechanical protection guidelines. Door frames shall be constructed of extruded aluminum angles
- F. Doors shall be of the same material type as the unit casing.
 - 1. Doors shall open against positive pressure. Alternatively, if doors opening against positive pressure are not available, a safety mechanism and warning label shall be provided to prevent injury to maintenance personnel.
 - 2. Access doors shall be provided with a separate handle for each latching point. Minimum of 2 latches supplied per door.
 - 3. All access doors shall have stainless steel hardware.
 - 4. All exterior door handles shall be UV rated, corrosion resistant glass reinforced nylon.
 - 5. All access doors shall have roller cam mechanisms to assist in compression of seal. Rotating knife-edge or "paw" latches are not acceptable.
 - 6. All access doors shall have zinc door hold backs.
 - 7. All access doors shall have stainless steel door safety chains.

8. Access doors shall have Ventlok No. 699 instrument test holes. The test holes shall be installed in door locations as shown on the unit elevation details.
9. Viewing windows shall be provided as shown on the unit elevation details. View windows shall be of a non-condensing type consisting of an integrated silica desiccant dehumidification layer. Viewports supplied as 8"x8" or 12"x12" as allowed by door size.

2.4 PIPE-CHASE

- A. Where indicated, air handling unit(s) shall be provided with an external pipe chase consisting of casing equivalent to the unit casing, having a minimum thermal conductivity R of 12 hr-ft²-°F/BTU. Field piping and valves shall be fully contained in pipe chase. Pipe-chase enclosures of adjacent segments shall be combined to be a continuous open pipe-chase.
 1. Pipe-chase shall provide sufficient space for coil connections to be installed without interference.
 2. Loose-shipped pipe-chase enclosures shall be provided with lifting lugs for field installation.
 3. Pipe chase floor construction shall be the same as that of the unit external pipe chase.

2.5 SUPPLY AND RETURN FAN (DIRECT DRIVE)

- A. Manufacturers:
 1. Greenheck
 2. Loren Cook
- B. Fan shall be a single width, single inlet backward inclined centrifugal airfoil, direct driven or belt driven plenum blower as specified.
- C. Fan shall be manufactured at an ISO 9001 certified facility. Fan shall be listed by UL 7050. Fan shall bear the AMCA Certified Ratings Seal for Sound and Air Performance. Performance shall be certified for both inlet and outlet sound.
- D. The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The inlet panel shall be constructed from heavy gauge reinforced steel with an integral rectangular formed duct

connection. High performance airflow baffle shall be standard to reduce under-unit turbulence and improve efficiency. Integral lifting points shall be standard. Unit shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM, static pressure and maximum fan RPM. Unit shall be shipped in ISTA Certified Transit Tested Packaging.

- E. Steel fan components shall have an electrostatically applied, baked polyester powder coating. Each component shall have a minimum 2 mil thick baked powder finish. Paint must exceed 1,000 hour salt spray under ASTM B117 test method.
- F. Wheel shall be steel, non-overloading centrifugal backward inclined, high efficiency, airfoil type. Blades on all sizes shall be continuously welded to the back plate and inlet shroud. All sizes shall be securely keyed to the fan shaft. Wheel shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-96, Balance Quality and Vibration Levels for Fans.
- G. Motor shall be heavy duty type with permanently lubricated sealed ball bearings and furnished at the specified voltage, phase, and enclosure.
- H. Blower shaft shall be AISI C-1045 hot rolled and accurately turned, ground and polished. Shafting shall be sized for a critical speed of at least 125% of maximum RPM.
- I. Bearings shall be designed and tested specifically for use in air handling applications. Construction shall be heavy duty regreasable ball or roller type in a cast iron pillow block housing selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed.
- J. Plenum fans shall be belt-driven or direct-drive as indicated in Schedule.
- K. All re-greasable bearings shall be factory lubricated and equipped with standard hydraulic grease fittings and lube lines extended to the motor side of the fan as standard to the exterior of the unit. Re-greaseable

bearings provided without factory installed lubrication lines are unacceptable.

- L. Fan drives shall be selected for a 1.5 service factor and anti-static belts shall be furnished.
 - 1. All drives 15 hp or smaller on constant volume units shall be adjustable pitch. Drives 20 hp or larger or any drives on units equipped with VFDs shall be fixed pitch.
 - 2. All fans shall be equipped with multiple belt drives (if any), as specified.
 - 3. Sheaves shall be machined from a close grain cast iron and statically balanced by the manufacturer. A fixed pitch sheave shall be provided on the motor.
 - 4. Drive belts shall be a V type. All drive belts shall be precision molded raw edge construction. Belts shall be oil and heat resistant.

2.6 ELECTRICAL CHARACTERISTICS AND COMPONENTS

- A. Fan motors will be furnished in sizes, electrical power and starting characteristics as shown in the schedule.
 - 1. All fan motors will be built in accordance with the latest standards of the National Electrical Manufacturer's Association (NEMA) and IEEE and shall be rated for continuous duty at full load at 40°C ambient temperature rise and a service factor of 1.15.
 - 2. Fan motors shall be NEMA design ball bearing type.
 - 3. Fan motors shall be 1800 RPM totally enclosed, fan cooled type.
 - 4. Direct drive plenum fans shall be coupled with appropriately sized motors to nearly match synchronous motor speed, as detailed in the schedule.
 - 5. All fan motors shall be NEMA premium efficiency, inverter duty rated.
- B. The air-handling unit shall be power wired for separate, dedicated power source for lights, having one switch, separate from the Motor power source entrance. Lighting circuit shall receive power circuit installed by Electrical Contractor.
- C. Marine lights shall be provided throughout AHUs as indicate on the schedule and drawings. Lights shall be fluorescent type to minimize amperage draw and shall produce lumens equivalent to a minimum 64 W,

instant-start bulb. Lights shall be constructed of safety glass. Lights shall be suitable for wet locations.

- D. All lights on a unit shall be wired in the factory to a single on-off switch. On outdoor units, the light switch shall be mounted inside the unit at the fan access door. On indoor units, the light switch shall be mounted on the casing exterior in a NEMA 1 enclosure next to the fan access door.

2.7 PIPING SYSTEMS

- A. All piping systems addressed below must meet the minimum testing requirements as stated below. All test results must show no measurable sign of leakage or additional pressure drop. If leaks are present, the system must be repaired and retested until the system passes.
 - 1. Water Systems: Hydrostatic pressure test shall be performed using a water at 75 psig for a minimum duration of 2 hours.
- B. Factory installed chilled and hot water piping shall include welded, threaded, or flanged or pipe couplings, fittings, and valves.
 - 1. Water piping shall be Schedule 40 black steel pipe or Type L copper.
 - 2. Piping 2" and smaller shall be threaded type with 150# rated fittings and valves.
 - 3. Piping 2.5" and larger shall be welded type with 150# rated fittings and valves, flange.
 - 4. Factory installed pipe supports shall be equal to Unistrut Corporation vertical support members, including Unistrut pipe clamps.
 - 5. Piping insulation shall be field supplied and field installed by others.

2.8 HEATING/COOLING COMPONENTS

- A. Coil segment length shall be optimized to contain selected coil(s), spacer(s), and access doors. Coils shall be selected to maximize unit tunnel area using stacked coil arrangements as needed to satisfy required coil face areas.
 - 1. Coil segment design and coil selection shall not require a drain pan in any downstream section to contain the coil condensate.

2. All cooling and/or heating coils shall be furnished to meet the performance requirements set forth in the schedule.
3. All water and steam coils shall have performance certified in accordance with AHRI Standard 410 for coil capacity and pressure drop.
4. All coils must be circuited to operate at design load with water velocity within the AHRI range of certified rating conditions.
5. Multiple coils in a single coil segment shall be separated by stainless steel coil spacers. Coil spacers should accommodate side-access via a removable side-plate.
6. Coil segment side panels shall be removable to allow for removal and replacement of coils, without affecting the structural integrity of the unit.
7. Upstream and downstream segment door clearances shall accommodate a minimum of 2-inches of field-installed external piping insulation.
8. Coil segment shall accommodate full-face height or reduced face height coils, as specified.

- B. Cooling Coil Segment shall be provided with a full-width, multi-sloped (IAQ) drain pan that extends downstream a minimum 6" beyond the last coil in the section to provide drain pan access for cleaning and inspection.
- C. IAQ Drain Pan design and application shall comply fully with the stated intent of ASHRAE 62.1-2010. Units with cooling coils shall have drain pans under complete cooling coil section.
 - 1. The IAQ Drain Pan shall be double sloped, positive draining with stainless steel pan. Pan design must ensure that water drains freely from the pan whether the fan is in operation or stagnant. P-Trap guidelines shall be affixed to the unit. P-Trap components to be provided and installed by the jobsite contractor.
 - 2. Coat IAQ drain pan with an anti-microbial coating to reduce microbial growth contaminating the air stream.
 - 3. Drain connection shall be located at the lowest point(s) of the pan, per ASHRAE 62.1-2010. Drain connection shall be of like material as liner, draining to one side of the unit.
 - 4. IAQ Drain Pan must allow visual inspection and physical cleaning, including underneath coils, without removal of the coil.
 - 5. All coils shall be slide out, "shipping" type, mounted on tracks, and easily removable from the air handling unit by removing only one exterior panel. Coils that require additional disassembly of the unit or replacement of the entire coil section (e.g. "unit" type coils) for coil removal are unacceptable.
- D. All vertical coil supporting members (bulkheads) and blockoffs shall be constructed of stainless steel and shall entirely seal off the coil, preventing air bypass.
- E. Coil grommets shall be provided on all coils to completely seal the area between the coil connection and the unit casing. Adhesive rings applied to the casing walls are not acceptable.
- F. Drainable Water coils shall be designed to operate at 250 psig design working pressure and up to 300° F and shall be tested with 325 psig compressed air under water. Circuiting shall provide free and complete draining and venting when installed in the unit. All vent and drain connections shall be extended to the outside of the unit casing.

- G. The primary surface shall be 5/8" O.D. copper tube, staggered in direction of airflow. Tubes shall be mandrel expanded to form fin bond and provide burnished, work-hardened interior surface. The tubes shall have a minimum tube wall thickness of 0.025". Specified thickness shall be maintained throughout the tube including brazed U-bends.
- H. Extended surface shall consist of die-formed, continuous, aluminum corrugated fins. The fins shall have fully drawn collars to accurately space fins, and to form a protective sheath for the primary surface. The fin thickness shall be 0.006".
- I. Coils with finned height greater than 48 inches shall have an intermediate drain pan extending the entire finned length of the coil. Cooling coils in excess of 48 inches in height shall not be acceptable unless provided with an intermediate drain pan. The intermediate pans shall have copper down spouts to guide condensate to the main drain pan.

- J. Coil casing shall be constructed of 16-gauge galvanized steel. Tube sheets on each end shall have drawn collars to support tubes. A single intermediate coil support shall be provided on coils with a finned length of more than 62 inches, two (2) intermediate supports above 100 inches in length, and three (3) intermediate supports on coils with a finned length of more than 141 inches. Casing channels shall be free-draining, without depressions to collect moisture and contaminants. Casing channels shall not block fin area.
- K. Headers shall be of heavy seamless copper tubing, silver-brazed to tubes. Connections shall be of steel, with male pipe threads, silver-brazed to the headers. All vent and drain connections.
- L. Circuiting shall be to provide free draining and venting, through one vent and one drain on each coil, when installed with casing level. Coils shall be circuited, and have connections arranged, for counter-flow of air and water with supply on bottom and return on top of coil headers. Coil circuiting shall provide for design water velocity in tubes without exceeding total water pressure drops in schedule.
- M. Coils using turbulators are unacceptable.
- N. Coils to be manufactured by Luvata or approved equal.

2.9 FILTERS

- A. Filters shall be provided with front-loading frames. Filter holding frames shall be constructed of galvanized steel and equipped with foam gaskets to seal filters against filter frames. Frame seams shall be sealed to eliminate air bypass. Front-loading frames shall be equipped with filter fasteners of the same material as the filter frame. Filter fasteners shall be capable of being installed without the use of special tools, bolts or nuts. Filter holding frames shall be of a universal type to accommodate standard filters of the same nominal size as well as appropriate fasteners. Filter access shall be as indicated on the drawings.
- B. Pre-Filter Segments shall be provided with pleated MERV 8, 2" media.
- C. Final Filter shall accommodate bag type media. Media shall be long bag

MERV 14. Segment to include MERV 8 pre-filter.

D. Provide magnehelic gages with tap for BMS connection at each filter section.

E. Provide all hardware and trim accessories for filters manufactured by Viledon.

2.10 DAMPERS

A. Ultra low-leak modulating, opposed-blade dampers shall be provided. Damper blades shall be galvanized double-skin airfoil design for minimal pressure drop. Leakage rate shall not exceed 3 cfm/square foot at 1" w.g. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D. All dampers shall be mounted on the AHU interior.

2.11 DIFFUSERS

A. Diffuser segments shall be provided as shown on drawings.

B. Diffuser plates shall ensure proper air flow across components downstream of DWDI fans.

C. Inlet diffusers shall be supplied as shown on drawings to direct airflow into inlet openings of plenum-style return fans.

2.12 VIBRATION ISOLATION

A. All fan and motor assemblies shall be mounted on vibration isolators which have a 2" deflection to isolate the assembly from the unit housing. The discharge of housed fan assemblies and the inlet of plenum fan assemblies shall be connected to the pressure-bulkhead panel (wall, floor, or roof) with flexible duct to prevent transmission of vibration to the unit casing. No metal-to-metal contact will be permitted between fixed and floating parts. Thrust restraints shall be provided as required to limit horizontal movement of fan assembly at design conditions. Fan bases shall be rigidly tied to the unit base during shipment to prevent damage from shipping vibrations.

2.13 FACTORY TESTING

- A. Perform factory test on fully assembled units with sections joined per manufacturer's installation instructions. Use of additional material (tape, sealant, and caulk) shall be minimized to only that required to simulate permanent jobsite conditions not otherwise duplicable in the factory.
- B. A written report shall be provided showing the test results and the test methods used.
- C. Perform tests to verify the following performance criteria:
 - 1. Casing leakage shall not exceed 0.5% of design CFM at +/-12" w.g.
 - 2. Casing panel deflection shall not exceed L/200 at +/- 12" w.g. 'L' is defined as the panel span length and 'L/X' is the deflection at panel midpoint.
- D. Should a unit fail a test, the unit shall be treated with a permanent remedy at manufacturer's expense until test is successfully passed.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install equipment per industry standards, applicable codes, and manufacturer's instructions.
- B. Install AHUs on a concrete pad, roof curb, or structural steel base, as shown on drawings.
- C. Install AHUs with manufacturer's recommended clearances for access, coil pull, and fan removal.
- D. Provide one complete set of filters for testing, balancing, and commissioning. Provide second complete set of filters at time of final inspection. Provide spare set of filters as indicated above.
- E. Install AHU plumb and level. Connect piping and ductwork according to manufacturer's instructions.
- F. Install seismic restraints and anchors per Section 23 05 48.

- G. Insulate plumbing associated with drain pan drains and connections.

3.2 FIELD QUALITY CONTROL

- A. Store per AHU manufacturer's written recommendations. Store AHUs indoors in a warm, clean, dry place where units will be protected from weather, construction traffic, dirt, dust, water and moisture. If units will be stored for more than 6 months, follow manufacturer's instruction for long-term storage.
- B. Rig and lift units according manufacturer's instructions.

3.3 AHU INSPECTION

- A. Contractor shall inspect and provide written verification of verify the following:
 - 1. Damage of any kind to unit during shipping.
 - 2. Level installation of unit.
 - 3. Proper reassembly and sealing of unit segments at shipping splits.
 - 4. Tight seal around perimeter of unit at the roof curb.
 - 5. Installation of shipped-loose parts, including filters, air hoods, bird screens and mist eliminators.
 - 6. Completion and tightness of electrical, ductwork and piping connections.
 - 7. Tight seals around wiring, conduit and piping penetrations through AHU casing.
 - 8. Supply of electricity from the building's permanent source.
 - 9. Integrity of condensate trap for positive or negative pressure operation.
 - 10. Condensate traps charged with water.
 - 11. Removal of shipping bolts and shipping restraints
 - 12. Sealing of pipe chase floor(s) at penetration locations.
 - 13. Tightness and full motion range of damper linkages (operate manually).
 - 14. Complete installation of control system including end devices and wiring.
 - 15. Cleanliness of AHU interior and connecting ductwork.
 - 16. Proper service and access clearances.
 - 17. Proper installation of filters.
 - 18. Filter gauge set to zero.
 - 19. All field-installed controls components are in place.

- B. Resolve any non-compliant items prior to proceeding with AHU functioning test.

3.4 AHU FAN INSPECTION

- A. Contractor shall inspect and provide written verification of the following:
 - 1. Fan isolation base and thrust restraint alignment
 - 2. Tight set screws on pulleys, bearings and fan.
 - 3. Tight fan bearing bolts.
 - 4. Tight fan and motor sheaves.
 - 5. Tight motor base and mounting bolts.
 - 6. Blower wheel tight and aligned to fan shaft.
 - 7. Sheave alignment and belt tension.
 - 8. Fan discharge alignment with discharge opening.
 - 9. Fan bearing lubrication.
 - 10. Free rotation of moving components (rotate manually).
 - 11. Shipping restraints have been removed.

3.5 STARTUP SERVICE

- A. Manufacturer's factory-authorized service technician shall startup AHUs. Technician shall perform the following:
 - 1. Energize the unit disconnect switch / VFD.
 - 2. Verify correct voltage, phases and cycles.
 - 3. Energize fan motor briefly ("bump") and verify correct direction of rotation.
 - 4. Re-check damper operation; verify that unit cannot and will not operate with all dampers in the closed position.
 - 5. Energize fan motors and verify that motor FLA is within manufacturer's tolerance of nameplate FLA for each phase.
- B. Submit a startup report summarizing any problems found and remedies performed.

3.6 CLEANING

- A. Remove all foreign objects and thoroughly clean the interior and exterior surfaces of the units with a mild detergent (soap and water). Do not use any abrasives or solvents without first consulting the Manufacturer.

- B. Clean AHU exterior prior to final inspection.

3.7 DOCUMENTATION AND OWNER TRAINING

- A. Provide Installation Instruction Manual & Startup checklist in the supply fan section of each unit.
- B. Provide a minimum of 2 hours of training for owner's personnel service technician.
- C. Training shall include startup and shutdown procedures as well as regular operation and maintenance requirements.
- D. Provide required number of copies of manufacturer's operation and maintenance manuals. See Division 1 for additional requirements.

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SECTION 23 82 16
AIR COILS

PART 1 - GENERAL

1.1 DESCRIPTION

Heating and cooling coils for air handling unit and duct applications

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Section 23 31 00, HVAC DUCTS AND CASINGS
- C. Section 23 36 00, AIR TERMINAL UNITS: Reheat coils for VAV/CV terminals.
- D. Section 23 74 13, CUSTOM CENTRAL STATION AIR HANDLING UNITS.
- E. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.
- F. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE, Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Unless specifically exempted by these specifications, heating and cooling coils shall be tested, rated, and certified in accordance with AHRI Standard 410 and shall bear the AHRI certification label.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data for Heating and Cooling Coils: Submit type, size, arrangements and performance details. Present application ratings in the form of tables, charts or curves.
- C. Provide installation, operating and maintenance instructions.
- D. Certification Compliance: Evidence of listing in current ARI Directory of Certified Applied Air Conditioning Products.
- E. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. Air Conditioning and Refrigeration Institute (AHRI):

Directory of Certified Applied Air Conditioning Products

AHRI 410-01.....Forced-Circulation Air-Cooling and Air-Heating
Coils

C. American Society for Testing and Materials (ASTM):

B75/75M-02.....Standard Specifications for Seamless Copper Tube

PART 2 - PRODUCTS

2.1 HEATING AND COOLING COILS

- A. Conform to ASTM B75 and AHRI 410.
- B. Tubes: Minimum 0.625 inch tube diameter; Seamless copper tubing.
- C. Fins: 0.0055 inch aluminum or 0.0045 inch copper mechanically bonded or soldered or helically wound around tubing.
- D. Headers: Copper, welded steel or cast iron. Provide seamless copper tubing or resistance welded steel tube for volatile refrigerant coils.
- E. "U" Bends, Where Used: Machine die-formed, silver brazed to tube ends.
- F. Coil Casing: 16 gage galvanized steel with tube supports at 48 inch maximum spacing. Construct casing to eliminate air bypass and moisture carry-over. Provide duct connection flanges.
- G. Pressures kPa (PSIG):
- H. Protection: Unless protected by the coil casing, provide cardboard, plywood, or plastic material at the factory to protect tube and finned surfaces during shipping and construction activities.
- I. Vents and Drain: Coils that are not vented or drainable by the piping system shall have capped vent/drain connections extended through coil casing.

2.2 REHEAT COILS, DUCT MOUNTED

The coils shall be continuous circuit booster type for steam or hot water as shown on drawings. Use the same coil material as listed in Paragraphs 2.1.

2.3 WATER COILS

- A. Use the same coil material as listed in Paragraphs 2.1.
- B. Drainable Type (Self Draining, Self Venting); Manufacturer standard:
 - 1. Cooling, all types.
 - 2. Heating or preheat.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow coil manufacturer's instructions for handling, cleaning, installation and piping connections.
- B. Comb fins, if damaged. Eliminate air bypass or leakage at coil sections.

3.2 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.4 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

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Outpatient Services Center
G.V. (Sonny) Montgomery VA Medical Center, Jackson, MS

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