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

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe hangers and supports.
2. Hanger rods.
3. Inserts.
4. Flashing.
5. Equipment curbs.
6. Formed steel channel.
7. Firestopping and accessories for HVAC Work.
8. Equipment bases and supports.

B. Related Requirements:

1. Section 07 84 00 - Firestopping: Firestopping for placement by this Section.

1.2 DEFINITIONS

A. Firestopping (Through-Penetration Protection System): The material used to seal or stuff or an assembly placed in spaces between and penetrations through building materials to arrest movement of fire, smoke, heat, and hot gases through fire-rated construction.

1.3 REFERENCE STANDARDS

A. American Welding Society:

1. AWS D1.1/D1.1M - Structural Welding Code - Steel.

B. ASME International:

1. ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
2. ASME B31.9 - Building Services Piping.

C. ASTM International:

1. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
2. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems.
3. ASTM E1966 - Standard Test Method for Fire-Resistive Joint Systems.

4. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.

D. FM Global:

1. FM - Approval Guide.

E. Manufacturers Standardization Society of the Valve and Fittings Industry:

1. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

F. UL:

1. UL - Fire-resistance-rated Systems and Products.
2. UL 263 - Fire Tests of Building Construction and Materials.
3. UL 1479 - Fire Tests of Through-Penetration Firestops.
4. UL 2079 - Tests for Fire Resistance of Building Joint Systems.

1.4 SUBMITTALS

A. Delegated Design Submittals:

1. Submit signed and sealed Shop Drawings with design calculations and assumptions for load-carrying capacity of trapeze, multiple-pipe, and riser support hangers.

1.5 QUALITY ASSURANCE

A. Through-Penetration Firestopping of Fire-Rated Assemblies:

1. Comply with UL 1479 or ASTM E814.
2. Positive Pressure Differential:

    a. As required to achieve fire F-ratings and temperature T-ratings as indicated on Drawings, but not less than one hour.
    b. Minimum 0.10 inch wg.

3. Wall Penetrations: Fire F-ratings as indicated on Drawings, but not less than one hour.
4. Roof Penetrations:

    a. Fire F-ratings and temperature T-ratings as indicated on Drawings, but not less than one hour.
    b. Floor Penetrations within Wall Cavities: T-rating not required.

B. Through-Penetration Firestopping of Non-fire-rated Roof Assemblies:

1. Materials: Resist free passage of flame and products of combustion.
2. Noncombustible Penetrating Items: Connecting maximum three stories.

3. Penetrating Items: Materials approved by authorities having jurisdiction for connecting maximum two stories.

C. Fire-Resistive Joints in Fire-Rated Floor, Roof, and Wall Assemblies:

1. Comply with [ASTM E1966 or] UL 2079.
2. As required to achieve fire-resistance rating as indicated on Drawings for assembly in which joint is installed.

D. Surface-Burning Characteristics:

1. Maximum 25/450 flame-spread/smoke-developed index.
2. Testing: Comply with ASTM E84.

E. Welding of Hanger and Support Attachments to Building Structure: Comply with applicable authority.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

B. Store materials according to manufacturer instructions.

C. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Provide additional protection according to manufacturer instructions.

1.7 AMBIENT CONDITIONS

A. Minimum Conditions:

1. Do not apply firestopping materials if temperature of substrate material and ambient air is below 60 degrees F.
2. Maintain this minimum temperature before, during, and for minimum three days after installation of firestopping materials.

B. Provide ventilation in areas to receive solvent cured materials.

1.8 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.

2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. Firestopping Materials:

1. Comply with [ASTM E119] [, ASTM E814] [, UL 263] [, and] [UL 1479].
2. Adjacent Construction:

a. Achieve fire ratings as indicated on Drawings for adjacent construction.
b. Minimum Fire Rating: One hour.

B. Firestop interruptions to fire-rated assemblies, materials, and components.

2.2 PERFORMANCE AND DESIGN CRITERIA

A. Firestopping:

1. Comply with applicable code for fire-resistance ratings and surface-burning characteristics.

2.3 PIPE HANGERS AND SUPPORTS

A. Manufacturers:

1. CADDY; nVent.
2. Carpenter & Paterson, Inc.
3. Empire Industries, Inc.
4. Globe Pipe Hanger Products Incorporated.
5. Haydon Corporation.
6. Hilti, Inc.
7. NIBCO INC.
8. PHD Manufacturing, Inc.
9. PHS Industries, Inc.
10. Unitron Product, Inc. / US-Strut.

B. Hydronic Piping:

1. Comply with ASME B31.9.
2. Hangers for Pipe Sizes 1/2 Inch to 1-1/2 Inches:

a. Material: Malleable iron.
b. Type: Adjustable swivel and split ring.

3. Hangers for Cold Pipe, Sizes 2 Inches and Larger:

    a. Material: Carbon steel.
    b. Type: Adjustable; clevis.

4. Hangers for Hot Pipe, Sizes 2 to 4 Inches:

    a. Material: Carbon steel.
    b. Type: Adjustable; clevis.

5. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
6. Copper Pipe Support: Copper-plated carbon-steel ring.

C. Refrigerant Piping:

1. Conform to ASME B31.5.
2. Hangers for Pipe Sizes 1/2 Inch to 1-1/2 Inches: Malleable iron adjustable swivel, split ring.
3. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
4. Copper Pipe Support: Copper-plated carbon-steel ring.

D. Accessories:

1. Hanger Rods: Mild steel threaded both ends.

2.4 INSERTS

A. Manufacturers:

1. CADDY; nVent.
2. Carpenter & Paterson, Inc.
3. National Pipe Hanger Corporation.
4. PHS Industries, Inc.
5. Pipe Shields Inc.
6. Piping Technology & Products, Inc.
7. Rilco Manufacturing Co., Inc.
8. Unitron Product, Inc. / US-Strut.
9. Value Engineered Products, Inc.

B. Description:

1. Malleable iron case with galvanized steel shell and expander plug for threaded connection.
2. Lateral adjustment, top slot for reinforcing rods, and lugs for attaching to forms.
3. Size: To suit threaded hanger rods.

2.5 FLASHING

A. Metal Flashing:

1. Material: Galvanized steel.
2. Thickness: [26] _____ gage.

B. Metal Counterflashing:

1. Material: Galvanized steel.
2. Thickness: [22] _____ gage.

2.6 EQUIPMENT CURBS

A. Manufacturers:

1. Lloyd Industries, Inc.
2. LMCurbs.
3. Metal Form Manufacturing, Inc.
4. Pate Company (The).
5. Roof Products, Inc.

B. Description:

1. Shell and Base: Welded 18-gage galvanized steel.
2. Cant: Mitered; 3 inches.
3. Insulation Thickness: 1-1/2 inches.
4. Wood Nailer: Factory installed.

2.7 FORMED STEEL CHANNEL

A. Manufacturers:

1. B-line; Eaton, Electrical Sector.
2. Unistrut; Atkore International.

B. Description:

1. Material: Galvanized 12-gage steel.
2. Thickness: 12 gage.
3. Hole Spacing: 1-1/2 inches o.c.

2.8 FIRESTOPPING

A. Firestopping Materials: As specified in Architectural sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that openings are ready to receive sleeves.

B. Verify that openings are ready to receive firestopping.

3.2 INSTALLATION

A. Inserts:

1. Install inserts for placement in concrete forms.
2. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe 4 inches and larger.
4. If concrete slabs form finished ceiling, locate inserts flush with slab surface.
5. If inserts are omitted, drill through concrete slab from below and provide through bolt with recessed square steel plate and nut [above] [flush with top of] [recessed into and grouted flush with] slab.

B. Pipe Hangers and Supports:

1. Comply with ASME B31.1.
2. Support horizontal piping as scheduled.
3. Minimum Hanger Spacing: 1/2 inch between finished covering and adjacent Work.
4. Place hangers within 12 inches of each horizontal elbow.
5. Minimum Vertical Hanger Adjustment: 1-1/2 inches.
6. If piping is installed in parallel and at same elevation, provide multiple-pipe or trapeze hangers.
7. Provide copper-plated hangers and supports for copper piping.
8. Design hangers for pipe movement without disengagement of supported pipe.
9. Painting and Coating:

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

10. Insulation:

    a. Provide clearance in hangers and from structure and other equipment for installation of insulation.

C. Flashing:

1. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weatherproofed or waterproofed walls, floors, and roofs.
2. For sound control, provide acoustical-lead flashing around ducts and pipes penetrating equipment rooms.
3. Curbs:

    a. Provide curbs for roof installations with minimum height of 18 inches above roofing surface.
    b. Flash and counterflash with sheet metal and seal watertight.
    c. Attach counterflashing to equipment and lap base flashing on roof curbs.
    d. Flatten and solder joints.

4. Storm Collars:

    a. Adjust storm collars tight to pipe with bolts and calk around top edge.
    b. Install storm collars above roof jacks.
    c. Screw vertical flange section to face of curb.

D. Sleeves:

1. Exterior Watertight Entries: Seal with mechanical sleeve seals.
2. Set sleeves in position in forms and provide reinforcing around sleeves.
3. Sizing:

    a. Size sleeves large enough to allow for movement due to expansion and contraction.
    b. Provide for continuous insulation wrapping.

4. Extend sleeves through floors 1 inch above finished floor level, and calk sleeves.
5. Spaces:

    a. If piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent Work with firestopping insulation and calk airtight.
    b. Provide close-fitting metal collar or escutcheon covers at both sides of penetration.
    c. Install stainless-steel escutcheons at finished surfaces.

3.3 ATTACHMENTS

A. Pipe Hanger Spacing:

1. Pipe Material: Copper tube.

    a. Size: 1-1/4 inches and smaller.
    b. Maximum Hanger Spacing: 6 feet.
    c. Hanger Rod Diameter: 1/2 inch.

2. Pipe Material: Copper tube.

    a. Size: 1-1/2 inches and larger.
    b. Maximum Hanger Spacing: 10 feet.
    c. Hanger Rod Diameter: 1/2 inch.

3. Pipe Material: Steel.

    a. Size: 3 inches and smaller.
    b. Maximum Hanger Spacing: 12 feet.
    c. Hanger Rod Diameter: 1/2 inch.

4. Pipe Material: Steel.

    a. Size: 4 inches and larger.
    b. Maximum Hanger Spacing: 12 feet.
    c. Hanger Rod Diameter: 5/8 inch.

END OF SECTION 23 05 29

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Nameplates.
2. Tags.
3. Stencils.
4. Pipe markers.
5. Labels.
6. Lockout devices.

1.2 REFERENCES

A. American Society of Mechanical Engineers:

1. ASME A13.1 - Scheme for the Identification of Piping Systems.

1.3 QUALITY ASSURANCE

A. Conform to ASME A13.1 for color scheme for identification of piping systems and accessories.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience.

B. Installer: Company specializing in performing Work of this section with minimum three years' experience.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Nameplates

1. Manufacturers:

a. Craftmark Pipe Markers.

b. Kolbi Pipe Marker Co.
c. Pipemarker.com; Brimar Industries, Inc.
d. Seton Identification Products; a Brady Corporation company.

B. Product Description: Laminated three-layer plastic with engraved black letters on light contrasting background color.

2.2 TAGS

A. Plastic Tags

1. Manufacturers:

a. Brady ID.
b. Craftmark Pipe Markers.
c. Kolbi Pipe Marker Co.
d. Marking Services, Inc.
e. R & R Identification Co.
f. Seton Identification Products; a Brady Corporation company.

B. Metal Tags

1. Manufacturers:

a. Brady ID.
b. Craftmark Pipe Markers.
c. Kolbi Pipe Marker Co.
d. Marking Services, Inc.
e. Pipemarker.com; Brimar Industries, Inc.
f. R & R Identification Co.
g. Seton Identification Products; a Brady Corporation company.

C. Information Tags

1. Manufacturers:

a. Brady ID.
b. Seton Identification Products; a Brady Corporation company.
c. 1/4 x 5-5/8 inches with grommet and self-locking nylon ties.

D. Tag Chart: Typewritten letter size list of applied tags and location plastic laminated.

2.3 STENCILS

A. Stencils

1. Manufacturers:

a. Kolbi Pipe Marker Co.
b. Marking Services, Inc.
c. Pipemarker.com; Brimar Industries, Inc.
d. R & R Identification Co.
e. Seton Identification Products; a Brady Corporation company.

B. Stencils: With clean cut symbols and letters of following size:

1. Up to 2 inches Outside Diameter of Insulation or Pipe: 1/2-inch-high letters.
2. 2-1/2 to 6 inches Outside Diameter of Insulation or Pipe: 1-inch-high letters.
3. Ductwork and Equipment: 1-3/4 inches high letters.

2.4 PIPE MARKERS

A. Color and Lettering: Conform to ASME A13.1.

B. Plastic Pipe Markers

1. Manufacturers:

a. Brady ID.
b. Craftmark Pipe Markers.
c. Marking Services, Inc.
d. R & R Identification Co.

2. Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering. Larger sizes may have maximum sheet size with spring fastener.

C. Plastic Tape Pipe Markers

1. Manufacturers:

a. Brady ID.
b. Craftmark Pipe Markers.
c. Kolbi Pipe Marker Co.
d. Marking Services, Inc.
e. Pipemarker.com; Brimar Industries, Inc.
f. Seton Identification Products; a Brady Corporation company.

2. Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

2.5 LABELS

A. Labels:

1. Manufacturers:

a. Brady ID.
b. Seton Identification Products; a Brady Corporation company.

B. Description: Laminated Mylar, size 1.9 x 0.75 inches, adhesive backed with printed identification and bar code.

2.6 LOCKOUT DEVICES

A. Lockout Hasps

1. Manufacturers:

a. Brady ID.
b. Master Lock Company, LLC.

2. Reinforced nylon hasp with erasable label surface; size minimum 7-1/4 x 3 inches.

B. Valve Lockout Devices

1. Manufacturers:

a. Brady ID.
b. Master Lock Company, LLC.

PART 3 - EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

A. Apply stencil painting.

B. Install identifying devices after completion of coverings and painting.

C. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.

D. Install labels with sufficient adhesive for permanent adhesion and seal with clear lacquer. For unfinished canvas covering, apply paint primer before applying labels.

E. Install tags using corrosion resistant chain. Number tags consecutively by location.

F. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Identify in-line pumps and other small devices with tags.

G. Identify control panels and major control components outside panels with plastic nameplates.

H. Identify valves in main and branch piping with tags.

I. Identify air terminal units and radiator valves with numbered tags.

J. Tag automatic controls, instruments, and relays. Key to control schematic.

K. Identify piping, concealed or exposed, with plastic pipe markers and stenciled painting. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction.

L. Identify ductwork with stenciled painting. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

END OF SECTION 23 05 53

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

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Testing adjusting and balancing of air systems.
2. Testing adjusting and balancing of hydronic systems.
3. Measurement of final operating condition of HVAC systems.

B. Related Sections:

1. Section 23 09 23 - Direct-Digital Control System for HVAC: Requirements for coordination between DDC system and testing, adjusting, and balancing work.
2. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation for HVAC equipment.

1.2 REFERENCES

A. Associated Air Balance Council:

1. AABC MN-1 - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 111 - Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems.

C. Natural Environmental Balancing Bureau:

1. NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

D. Testing Adjusting and Balancing Bureau:

1. TABB - International Standards for Environmental Systems Balance.

1.3 SUBMITTALS

A. Prior to commencing Work, submit proof of latest calibration date of each instrument.

B. Test Reports: Indicate data on [**forms prepared following ASHRAE 111**] [**NEBB Report forms**] [**TABB Report Forms**].

C. Field Reports: Indicate deficiencies preventing proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

D. Submit draft copies of report for review prior to final acceptance of Project.

E. Furnish reports in electronic format, complete with table of contents page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

F. Provide a minimum of two (2) water system balances and four (4) air system balances.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Furnish final copy of testing, adjusting, and balancing report inclusion in operating and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with AABC MN-1 National Standards for Field Measurement and Instrumentation, Total System Balance [**TABB International Quality Assurance program**].

B. Prior to commencing Work, calibrate each instrument to be used.

1.6 QUALIFICATIONS

A. Agency: Company specializing in testing, adjusting, and balancing of systems specified in this section with minimum three (3) years' experience certified by AABC, Certified by NEBB or Certified by TABB.

1.7 SEQUENCING

A. Sequence balancing between completion of systems tested and Date of Substantial Completion.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify systems are complete and operable before commencing work. Verify the following:

1. Systems are started and operating in safe and normal condition.
2. HVAC control systems are installed complete and operable.
3. Proper thermal overload protection is in place for electrical equipment.
4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
5. Duct systems are clean of debris.
6. Fans are rotating correctly.
7. Fire and volume dampers are in place and open.
8. Air coil fins are cleaned and combed.
9. Access doors are closed and duct end caps are in place.
10. Air outlets are installed and connected.
11. Duct system leakage is minimized.
12. Hydronic systems are flushed, filled, and vented.
13. Service and balancing valves are open.

3.2 PREPARATION

A. Furnish instruments required for testing, adjusting, and balancing operations.

3.3 INSTALLATION TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 10 percent of design.

B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.4 ADJUSTING

A. Provide a minimum of two (2) hydronic system balances and four (4) air system balances.

B. Verify recorded data represents actual measured or observed conditions.

C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

D. After adjustment, take measurements to verify balance has not been disrupted. If disrupted, verify correcting adjustments have been made.

E. Report defects and deficiencies noted during performance of services, preventing system balance.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

G. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by Owner.

H. Check and adjust systems approximately six months after final acceptance and submit report.

3.5 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to obtain required or design supply, return, and exhaust air quantities.

B. Make air flow rate measurements in main ducts by Pitot tube traverse of entire cross-sectional area of duct.

C. Measure air quantities at air inlets and outlets.

D. Adjust distribution system to obtain:

1. Space temperatures within 2 degrees F.
2. Minimal objectionable drafts.

E. Use volume control devices to regulate air quantities only to extent adjustments do not create objectionable air motion or sound levels. Effect volume control by using volume dampers located in ducts.

F. Vary total system air quantities by adjustment of fan speeds. Provide sheave drive changes to vary fan speed. Vary branch air quantities by damper regulation.

G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across fan. Make allowances for 50 percent loading of filters.

I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

K. Measure building static pressure and adjust supply, return, and exhaust air systems to obtain required relationship between each to maintain approximately 0.10 inches differential static pressure in clean rooms and soiled rooms.

L. Check multi-zone units for motorized damper leakage. Adjust air quantities with mixing dampers set first for cooling, then heating, then modulating.

3.6 WATER SYSTEM PROCEDURE

A. Adjust water systems, after air balancing, to obtain design quantities.

B. Use calibrated or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow-metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in system.

C. Confirm air bleeds indicate system is full of water.

D. Adjust systems to obtain specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

E. Perform adjustment of water distribution systems by the following measures:

1. Reduce total system flow rate first by reducing speed of VFD.
2. Use balancing cocks, valves, and fittings.

F. Do not use service or shut-off valves for balancing unless designed for balancing and shut-off functions. Where available pump capacity is less than total flow requirements or individual system parts, simulate full flow in one part by temporary restriction of flow to other parts.

3.7 SCHEDULES

A. Partial list of Equipment Requiring Testing, Adjusting and Balancing:

1. Packaged Roof Top Heating/Cooling Units.
2. Air Coils.
3. Evaporative Humidifier.
4. Terminal Heat Transfer Units.
5. Air Handling Units.
6. Fans.
7. Air Inlets and Outlets.
8. Water Source Heat Pumps.
9. Energy Recovery Ventilators.

B. Report Forms

1. Title Page:

a. Name of Testing, Adjusting, and Balancing Agency
b. Address of Testing, Adjusting, and Balancing Agency
c. Telephone and facsimile numbers of Testing, Adjusting, and Balancing Agency
d. Project name
e. Project location
f. Project Architect
g. Project Engineer

h. Project Contractor
i. Project altitude
j. Report date

2. Summary Comments:

a. Design versus final performance
b. Notable characteristics of system
c. Description of systems operation sequence
d. Summary of outdoor and exhaust flows to indicate building pressurization
e. Nomenclature used throughout report
f. Test conditions

3. Instrument List:

a. Instrument
b. Manufacturer
c. Model number
d. Serial number
e. Range
f. Calibration date

4. Heating Coil Data:

a. Identification/number
b. Location
c. Service
d. Manufacturer
e. Air flow, design and actual
f. Water flow, design and actual
g. Water pressure drop, design and actual
h. Entering water temperature, design and actual
i. Leaving water temperature, design and actual
j. Entering air temperature, design and actual
k. Leaving air temperature, design and actual
l. Air pressure drop, design and actual

5. Water Source Heat Pump:

a. Manufacturer
b. Identification/number
c. Location
d. Model number
e. Size
f. Air flow, design and actual
g. Water flow, design and actual
h. Water pressure drop, design and actual
i. Entering water temperature, design and actual
j. Leaving water temperature, design and actual

k. Entering air temperature, design and actual
l. Leaving air temperature, design and actual

6. Energy Recovery Ventilators:

a. Location
b. Manufacturer
c. Model number
d. Serial number
e. Arrangement/Class/Discharge
f. Air flow, specified and actual
g. Return air flow, specified and actual
h. Outside air flow, specified and actual
i. Total static pressure (total external), specified and actual
j. Inlet pressure
k. Discharge pressure
l. Sheave Make/Size/Bore
m. Number of Belts/Make/Size
n. Fan RPM

7. Exhaust Fan Data:

a. Location
b. Manufacturer
c. Model number
d. Serial number
e. Air flow, specified and actual
f. Total static pressure (total external), specified and actual
g. Inlet pressure
h. Discharge pressure
i. Sheave Make/Size/Bore
j. Number of Belts/Make/Size
k. Fan RPM

END OF SECTION 23 05 93

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. HVAC piping insulation, jackets and accessories.
2. HVAC equipment insulation, jackets and accessories.
3. HVAC ductwork insulation, jackets, and accessories.

1.2 REFERENCES

A. ASTM International:

1. ASTM A240/A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
2. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
3. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
4. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
5. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation.
6. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
7. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
8. ASTM C585 - Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
9. ASTM C591 - Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
10. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
11. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
12. ASTM D4637 - Standard Specification for EPDM Sheet Used in Single-Ply Roof Membrane.
13. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials.
14. ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.

B. Sheet Metal and Air Conditioning Contractors:

1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

1.3 SUBMITTALS

A. Product Data: Submit product description, thermal characteristics and list of materials and thickness for each service, and location.

B. Manufacturer's Installation Instructions: Submit manufacturers published literature indicating proper installation procedures.

1.4 QUALITY ASSURANCE

A. Test pipe insulation for maximum flame spread index of 25 and maximum smoke developed index of not exceeding 50 in accordance with ASTM E84.

B. Pipe insulation manufactured in accordance with ASTM C585 for inner and outer diameters.

C. Factory fabricated fitting covers manufactured in accordance with ASTM C450.

D. Duct insulation, Coverings, and Linings: Maximum 25/50 flame spread/smoke developed index, when tested in accordance with ASTM E84, using specimen procedures and mounting procedures of ASTM E 2231.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and damage, by storing in original wrapping.

1.7 ENVIRONMENTAL REQUIREMENTS

A. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.

B. Maintain temperature before, during, and after installation for minimum period of 24 hours.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Glass Fiber and Mineral Fiber Insulation

1. Manufacturers:

a. CertainTeed LLC; Saint-Gobain North America.
b. Johns Manville; a Berkshire Hathaway company.
c. Knauf Insulation.
d. Manson Insulation Inc.
e. Owens Corning.

B. Closed Cell Elastomeric Insulation

1. Manufacturers:

a. Aeroflex USA.
b. Armacell LLC.
c. K-Flex USA.

2.2 PIPE INSULATION

A. TYPE P-1: ASTM C547, molded glass fiber pipe insulation.

1. Thermal Conductivity: 0.23 at 75 degrees F.
2. Operating Temperature Range: 0 to 850 degrees F.
3. Vapor Barrier Jacket: ASTM C1136, Type I, factory applied reinforced foil kraft with self-sealing adhesive joints.
4. Jacket Temperature Limit: minus 20 to 150 degrees F.

B. TYPE P-5: ASTM C534, Type I, flexible, closed cell elastomeric insulation, tubular.

1. Thermal Conductivity: 0.27 at 75 degrees F.
2. Operating Temperature Range: Range: Minus 70 to 180 degrees F.

2.3 PIPE INSULATION JACKETS

A. Vapor Retarder Jacket:

1. ASTM C921, white Kraft paper with glass fiber yarn, bonded to aluminized film.
2. Water Vapor Permeance: ASTM E96/E96M; 0.02 perms.

B. Aluminum Pipe Jacket:

1. ASTM B209.

2. Thickness: 0.016thick sheet.
3. Finish: Smooth _____.
4. Joining: Longitudinal slip joints and 2-inch laps.
5. Fittings: [0.016] _____ inch thick die shaped fitting covers with factory attached protective liner.
6. Metal Jacket Bands: [3/8 inch] [1/2 inch] wide; [[0.015] _____ inch thick aluminum.] [[0.010] [0.020] _____ inch thick stainless steel.]

2.4 PIPE INSULATION ACCESSORIES

A. Vapor Retarder Lap Adhesive: Compatible with insulation.

B. Piping 1-1/2 inches diameter and smaller: Galvanized steel insulation protection shield. MSS SP-69, Type 40. Length: Based on pipe size and insulation thickness.

C. Piping 2 inches diameter and larger: Wood insulation saddle, hard maple. Inserts length: not less than 6 inches long, matching thickness and contour of adjoining insulation.

D. Closed Cell Elastomeric Insulation Pipe Hanger: Polyurethane insert with aluminum single piece construction with self-adhesive closure. Thickness to match pipe insulation.

2.5 DUCTWORK INSULATION

A. TYPE D-1: ASTM C1290, Type III, flexible glass fiber, commercial grade with factory applied reinforced aluminum foil jacket meeting ASTM C1136, Type II.

1. Thermal Conductivity: 0.30 at 75 degrees F.
2. Maximum Operating Temperature: 250 degrees F.
3. Density: [0.75] [1.0] [1.5] pound per cubic foot.

B. TYPE D-2: ASTM C612, Type IA or IB, rigid glass fiber, with factory applied [all service facing] [reinforced aluminum foil facing] [metalized polypropylene scrim kraft facing] meeting ASTM C1136, Type II.

1. Thermal Conductivity: [0.24] [0.23] [0.22] at 75 degrees F.
2. Density: [1.6] [2.25] [3.0] [4.25] [6.0] pound per cubic foot.

2.6 DUCTWORK INSULATION JACKETS

A. Aluminum Duct Jacket:

1. ASTM B209.
2. Thickness: 0.016 inch thick sheet.
3. Finish: Smooth.
4. Joining: Longitudinal slip joints and 2-inch laps.
5. Fittings: [0.016] _____ inch thick die shaped fitting covers with factory attached protective liner.

B. Vapor Retarder Jacket:

1. [Kraft paper with glass fiber yarn and bonded to aluminized film] [0.0032 inch vinyl].
2. Water Vapor Permeance: ASTM E96/E96M; 0.02 perms.
3. Secure with pressure sensitive tape.

C. Canvas Duct Jacket: UL listed, 6 oz/sq yd, plain weave cotton fabric with fire retardant lagging adhesive compatible with insulation.

D. Membrane Duct Jacket: ASTM D4637; Type I, EPDM; non-reinforced, 0.045 inch thick, [48] _____ inch wide roll; white color.

2.7 DUCTWORK INSULATION ACCESSORIES

A. Vapor Retarder Tape:

1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber-based adhesive.

B. Vapor Retarder Lap Adhesive: Compatible with insulation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify [piping,] [equipment] [and] [ductwork] has been tested before applying insulation materials.

B. Verify surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION - PIPING SYSTEMS

A. Piping Exposed to View in Finished Spaces: Locate insulation and cover seams in least visible locations.

B. Continue insulation through penetrations of building assemblies or portions of assemblies having fire resistance rating of one hour or less. Provide intumescent firestopping when continuing insulation through assembly. Finish at supports, protrusions, and interruptions. Refer to Section 07 84 00 for penetrations of assemblies with fire resistance rating greater than one hour.

C. Piping Systems Conveying Fluids Below Ambient Temperature:

1. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.

2. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
3. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor retarder adhesive or PVC fitting covers.

D. Glass Fiber Board Insulation:

1. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
2. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.
3. Cover wire mesh or bands with cement to a thickness to remove surface irregularities.

E. Hot Piping Systems greater than [140] _____ degrees F:

1. Furnish factory-applied or field-applied standard jackets. Secure with outward clinch expanding staples or pressure sensitive adhesive system on standard factory-applied jacket and butt strips or both.
2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
3. Insulate flanges and unions at equipment.

F. Inserts and Shields:

1. Piping [1-1/2] _____ inches Diameter and Smaller: Install [galvanized] steel shield between pipe hanger and insulation.
2. Piping [2] _____ inches Diameter and Larger: Install insert between support shield and piping and under finish jacket.

    a. Insert Configuration: Minimum 6 inches long, of thickness and contour matching adjoining insulation; may be factory fabricated.
    b. Insert Material: Compression resistant insulating material suitable for planned temperature range and service.

3. Piping Supported by Roller Type Pipe Hangers: Install [galvanized] steel shield between roller and inserts.

G. Insulation Terminating Points:

1. Coil Branch Piping 1 inch and Smaller: Terminate hot water piping at union upstream of the coil control valve.
2. Condensate Piping: Insulate entire piping system and components to prevent condensation.

H. Closed Cell Elastomeric Insulation:

1. Push insulation on to piping.

2. Miter joints at elbows.
3. Seal seams and butt joints with manufacturer's recommended adhesive.
4. When application requires multiple layers, apply with joints staggered.
5. Insulate fittings and valves with insulation of like material and thickness as adjacent pipe.

I. High Temperature Pipe Insulation:

1. Install in multiple layers to meet thickness scheduled.
2. Attach each layer with bands. Secure first layer with bands before installing next layer.
3. Stagger joints between layers.
4. Finish with canvas jacket.
5. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.3 INSTALLATION - EQUIPMENT

A. Factory Insulated Equipment: Do not insulate.

B. Exposed Equipment: Locate insulation and cover seams in least visible locations.

C. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.

D. Equipment Containing Fluids Below Ambient Temperature:

1. Insulate entire equipment surfaces.
2. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
3. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
4. Finish insulation at supports, protrusions, and interruptions.

E. Equipment Containing Fluids Over [140] _____ degrees F:

1. Insulate flanges and unions with removable sections and jackets.
2. Install insulation with factory-applied or field applied jackets, with or without vapor barrier. Finish with glass cloth and adhesive.
3. Finish insulation at supports, protrusions, and interruptions.

F. Cover glass fiber insulation with aluminum jacket.

G. Nameplates and ASME Stamps: Bevel and seal insulation around; do not cover with insulation.

H. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation for easy removal and replacement without damage.

3.4 INSTALLATION - DUCTWORK SYSTEMS

A. Duct dimensions indicated on Drawings are finished inside dimensions.

B. Insulated ductwork conveying air below ambient temperature:

1. Provide insulation with vapor retarder jackets.
2. Finish with tape and vapor retarder jacket.
3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

C. Insulated ductwork conveying air above ambient temperature:

1. Provide with or without standard vapor retarder jacket.
2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

D. External Glass Fiber Duct Insulation:

1. Secure insulation with vapor retarder with wires and seal jacket joints with vapor retarder adhesive or tape to match jacket.
2. Secure insulation without vapor retarder with staples, tape, or wires.
3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
4. Seal vapor retarder penetrations by mechanical fasteners with vapor retarder adhesive.
5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

E. Ducts Exterior to Building:

1. Install insulation according to external duct insulation paragraph above.
2. Provide external insulation with vapor retarder jacket. Cover with outdoor jacket finished as specified.
3. Finish with membrane duct jacket.
4. Calk seams at flanges and joints. Located major longitudinal seams on bottom side of horizontal duct sections.

3.5 SCHEDULES

A. Condenser Water:

1. Type: P-1.

a. Thickness:

1) Pipe Size up to 3 inches

2. Condensate Piping from Cooling Coils:

a. Type: P-5 _____.
b. Thickness: 0.5 inch

3. Refrigerant Suction:

a. Type: P-5 _____.
b. Thickness: 0.5 inch

B. Heating Services Piping Insulation Schedule:

1. Heating Water Supply and Return, 141 to 200 degrees F:

a. Type: P-1 _____.
b. Thickness:

1) Pipe Size 3 Inches and Smaller: 1.0 inch
2) Pipe Size 4 Inches and Larger: 1.5 inches

2. Humidifier Supply Piping:

a. Type: P-1 _____.
b. Thickness:

1) Pipe Size 1-1/4 Inches and Smaller: 1.5 inches
2) Pipe Size 1-1/2 Inches and Larger: 2.0 inches

3. Humidifier Drain Piping:

a. Type: [P-1] _____.
b. Thickness: 1.0 inch

C. Ductwork Insulation Schedule:

1. Outside Air Intake:

a. Type: D-2.
b. Thickness: [1.5] [2.0] inch

2. Equipment Casings:

a. Type: [D-2].
b. Thickness: [1.0] [1.5] inch

3. Supply Ducts - Externally Insulated, Installed Thickness:

a. Type: D-1 and D-2.
b. Thickness: 1.5 inches

4. Return Ducts - Externally Insulated, Installed Thickness:

a. Type: D-1 and D-2.
b. Thickness: [1.0] [1.5] inches

5. Duct Coils:

a. Type: D-1.
b. Thickness: 1.5 inches

6. [Supply] [, Return] [, and] [Exhaust] Air - Exterior to Building on Roof:

a. Type: D-2.
b. Thickness: [2.0] _____ inches

7. Exhaust Ducts Within 10 feet of Exterior Openings, Installed Thickness:

a. Type: [D-1] [D-2].
b. Thickness: 1.5 inches

END OF SECTION 23 07 00

SECTION 23 08 00 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. HVAC commissioning description.
2. HVAC commissioning responsibilities.

B. Related Sections:

1. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC: For requirements and procedures concerning testing, adjusting, and balancing of mechanical systems.
2. Section 23 09 23 - Direct-Digital Control System for HVAC: Submittal, training, and programming requirements.
3. Section 23 33 00 - Air Duct Accessories: Product requirements for ductwork test holes.

1.2 REFERENCES

A. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE Guideline 1 - The HVAC Commissioning Process.

B. Building Commissioning Association:

1. BCA - Commissioning Handbook.

C. National Environmental Balancing Bureau:

1. NEBB - Procedural Standards for Building Systems Commissioning.

D. Testing Adjusting and Balancing Bureau:

1. TABB - Commissioning Manual.

1.3 COMMISSIONING DESCRIPTION

A. HVAC commissioning process includes the following tasks:

1. Testing and startup of HVAC equipment and systems.
2. Equipment and system verification checks.
3. Assistance in functional performance testing to verify testing and balancing, and equipment and system performance.
4. Provide qualified personnel to assist in commissioning tests, including seasonal testing.

5. Complete and endorse functional performance test checklists provided by Commissioning Authority to assure equipment and systems are fully operational and ready for functional performance testing.
6. Provide equipment, materials, and labor necessary to correct deficiencies found during commissioning process to fulfill contract and warranty requirements.
7. Provide operation and maintenance information and record drawings to Commissioning Authority for review verification and organization, prior to distribution.
8. Provide assistance to Commissioning Authority to develop, edit, and document system operation descriptions.
9. Provide training for systems specified in this Section with coordination by Commissioning Authority.

B. Equipment and Systems to Be Commissioned:

1. New HVAC systems that were installed under this Contract.
2. Existing HVAC systems that were modified, adjusted, upgraded, or affected by the work performed under this Contract.

C. The following is a partial list of equipment that may be included in this HVAC Commissioning:

1. Piping systems.
2. Ductwork.
3. Variable frequency drives.
4. Packaged roof top air conditioning units.
5. Humidifiers.
6. Air handling units.
7. Self-contained air conditioning units.
8. Water source heat pumps.
9. Hot water terminal heating equipment.
10. Fans.
11. Hospital room differential pressures.
12. Fire dampers.
13. Smoke dampers.
14. Automatic HVAC control system.
15. Testing, Adjusting and Balancing work.

D. Perform seasonal function performance tests for the following equipment and systems:

1. Heating equipment during heating season.
2. Cooling equipment during cooling season.

1.4 COMMISSIONING SUBMITTALS

A. Section 01 91 00 - Commissioning: Requirements for commissioning submittals.

B. Draft Forms: Submit draft of system verification form and functional performance test checklist.

C. Test Reports: Indicate data on system verification form for each piece of equipment and system as specified. Use AABC forms as guidelines.

D. Field Reports: Indicate deficiencies preventing completion of equipment or system verification checks equipment or system to achieve specified performance.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record revisions to equipment and system documentation necessitated by commissioning.

B. Operation and Maintenance Data: Submit revisions to operation and maintenance manuals when necessary revisions are discovered during commissioning.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with ASHRAE Guideline 1 requirements.

1.7 COMMISSIONING RESPONSIBILITIES

A. Equipment or System Installer Commissioning Responsibilities:

1. Attend commissioning meetings.
2. Ensure temperature controls installer performs assigned commissioning responsibilities as specified below.
3. Ensure testing, adjusting, and balancing agency performs assigned commissioning responsibilities as specified.
4. Provide instructions and demonstrations for Owner's personnel.
5. Ensure subcontractors perform assigned commissioning responsibilities.
6. Ensure participation of equipment manufacturers in appropriate startup, testing, and training activities when required by individual equipment specifications.
7. Develop startup and initial checkout plan using manufacturer’s startup procedures and functional performance checklists for equipment and systems to be commissioned.
8. During verification check and startup process, execute HVAC related portions of checklists for equipment and systems to be commissioned.
9. Perform and document completed startup and system operational checkout procedures, providing copy to Commissioning Authority.
10. Provide manufacturer’s representatives to execute starting of equipment. Ensure representatives are available and present during agreed upon schedules and are in attendance for duration to complete tests, adjustments and problem-solving.
11. Coordinate with equipment manufacturers to determine specific requirements to maintain validity of warranties.
12. Provide personnel to assist Commissioning Authority during equipment or system verification checks and functional performance tests.
13. Prior to functional performance tests, review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during tests.

14. Prior to startup, inspect, check, and verify correct and complete installation of equipment and system components for verification checks included in commissioning plan. When deficient or incomplete work is discovered, ensure corrective action is taken and re-check until equipment or system is ready for startup.
15. Perform verification checks and startup on equipment and systems as specified.
16. Assist Commissioning Authority in performing functional performance tests on equipment and systems as specified.
17. Conduct HVAC system orientation and inspection.

B. Temperature Controls Installer Commissioning Responsibilities:

1. Attend commissioning meetings.
2. Review design for ability of systems to be controlled including the following:

    a. Confirm proper hardware requirements exists to perform functional performance testing.
    b. Confirm proper safeties and interlocks are included in design.
    c. Confirm proper sizing of system control valves and actuators and control valve operation will result capacity control identified in Contract Documents.
    d. Confirm proper sizing of system control dampers and actuators and damper operation will result in proper damper positioning.
    e. Confirm sensors selected are within device ranges.
    f. Review sequences of operation and obtain clarification from Architect/Engineer.
    g. Indicate delineation of control between packaged controls and building automation system, listing BAS monitor points and BAS adjustable control points.
    h. Provide written sequences of operation for packaged controlled equipment. Equipment manufacturers? stock sequences may be included, when accompanied by additional narrative to reflect Project conditions.

3. Inspect, check, and confirm proper operation and performance of control hardware and software provided in other HVAC sections.
4. Submit proposed procedures for performing automatic temperature control system point-to-point checks to Commissioning Authority and Architect/Engineer.
5. Inspect check and confirm correct installation and operation of automatic temperature control system input and output device operation through point-to-point checks.
6. Demonstrate system performance and operation to Commissioning Authority during functional performance tests including each mode of operation.
7. Provide control system technician to assist during Commissioning Authority verification check and functional performance testing.
8. Provide control system technician to assist testing, adjusting, and balancing agency during performance of testing, adjusting, and balancing work.
9. Assist in performing operation and maintenance training sessions scheduled by Commissioning Authority.

C. Testing, Adjusting, and Balancing Agency Commissioning Responsibilities:

1. Attend commissioning meetings.
2. Participate in verification of testing, adjusting, and balancing report for verification or diagnostic purposes. Repeat 100 percent of measurements contained in testing, adjusting, and balancing report as indicated in Section 23 05 93.

3. Assist in performing operation and maintenance training sessions scheduled by Commissioning Authority.

1.8 SCHEDULING

A. Prepare schedule indicating anticipated start dates for the following:

1. Piping system pressure testing.
2. Piping system flushing and cleaning.
3. Ductwork cleaning.
4. Ductwork pressure testing.
5. Equipment and system startups.
6. Automatic temperature control system checkout.
7. Testing, adjusting, and balancing.
8. HVAC system orientation and inspections.
9. Operation and maintenance manual submittals.
10. Training sessions.

B. Schedule seasonal tests of equipment and systems during peak weather conditions to observe full-load performance.

C. Schedule occupancy sensitive tests of equipment and systems during conditions of both minimum and maximum occupancy or use.

1.9 COORDINATION

A. Notify Commissioning Authority minimum of four (4) weeks in advance of the following:

1. Scheduled equipment and system startups.
2. Scheduled automatic temperature control system checkout.
3. Scheduled start of testing, adjusting, and balancing work.

B. Coordinate programming of automatic temperature control system with construction and commissioning schedules.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install additional balancing dampers, balancing valves, access doors, test ports, and pressure and temperature taps required to meet performance requirements.

B. Place HVAC systems and equipment into full operation and continue operation during each working day of commissioning.

C. Install replacement sheaves and belts to obtain system performance, as requested by Commissioning Authority.

D. Install test holes in ductwork and plenums as requested by Commissioning Authority for taking air measurements.

E. Prior to start of functional performance test, install replacement filters in equipment.

3.2 FIELD TESTS AND INSPECTIONS

A. Seasonal Sensitive Functional Performance Tests:

1. Test heating equipment at winter design temperatures.
2. Test cooling equipment at summer design temperatures with fully occupied building.
3. Participate in testing delayed beyond Substantial Completion to test performance at peak seasonal conditions.

B. Be responsible to participate in initial and alternate peak season test of systems required to demonstrate performance.

C. Occupancy Sensitive Functional Performance Tests:

1. Test equipment and systems affected by occupancy variations at minimum and peak loads to observe system performance.
2. Participate in testing delayed beyond Substantial Completion to test performance with actual occupancy conditions.

END OF SECTION 23 08 00

SECTION 23 09 23 - DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARYs

A. Section includes control equipment and software.

B. Related Sections:

1. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation implemented using products specified in this section.

1.2 REFERENCES

A. American National Standards Institute:

1. ANSI MC85.1 - Terminology for Automatic Control.

1.3 SYSTEM DESCRIPTION

A. Automatic temperature controls field monitoring and control system using field programmable microprocessor based units.

B. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.

C. Provide computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.

D. Provide controls for reheat coils, heat pumps, rooftop units, humidifiers and energy recovery ventilators when directly connected to control units. Individual terminal unit.

E. Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories to operate mechanical systems, and to perform functions specified.

F. Provide installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

1.4 SUBMITTALS

A. Shop Drawings: Indicate the following:

1. Connected data points, including connected control unit and input device.
2. System configuration with peripheral devices, batteries, power supplies, diagrams, modems, routers, and interconnections.
3. Description and sequence of operation for operating, user, and application software.
4. Use terminology in submittals conforming to ASME MC85.1.

B. Product Data: Submit data for each system component and software module.

C. Manufacturer's Installation Instructions: Submit installation instruction for each control system component.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.

1. Revise shop drawings to reflect actual installation and operating sequences.
2. Submit data specified in "Submittals" in final "Record Documents" form.

B. Operation and Maintenance Data:

1. Submit interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
2. Submit keyboard illustrations and step-by-step procedures indexed for each operator function.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years’ experience, and with service facilities within 100 miles of Project.

1.7 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.8 MAINTENANCE SERVICE

A. Furnish service and maintenance of control systems for one year from Date of Substantial Completion.

B. Include systematic examination, adjustment, and lubrication of unit, and controls checkout and adjustments. Repair or replace parts in accordance with manufacturer's operating and maintenance data. Use parts produced by manufacturer of original equipment.

C. Perform work without removing units from service during building normal occupied hours.

D. Provide emergency call back service [**during working hours**] for this maintenance period.

E. Maintain locally, near Place of the Work, adequate stock of parts for replacement or emergency purposes. Have personnel available to ensure fulfillment of this maintenance service, without unreasonable loss of time.

F. Perform maintenance work using competent and qualified personnel under supervision of manufacturer or original installer.

PART 2 - PRODUCTS

2.1 DIRECT DIGITAL CONTROLS

A. Manufacturers:

1. Use building standard manufacturers or, if no standard, use one of the manufacturers listed below:

    a. Honeywell International Inc.
    b. Johnson Controls, Inc.
    c. Siemens Industry, Inc., Building Technologies Division.

2.2 CONTROL UNITS

A. Units: Modular in design and consisting of processor board with programmable RAM memory, local operator access and display panel, and integral interface equipment.

B. Battery Backup: For minimum of 48 hours for complete system including RAM without interruption, with automatic battery charger.

C. Control Units Functions:

1. Monitor or control each input/output point.
2. Completely independent with hardware clock/calendar and software to maintain control independently.
3. Acquire, process, and transfer information to operator station or other control units on network.
4. Accept, process, and execute commands from other control unit's or devices or operator stations.
5. Access both data base and control functions simultaneously.
6. Record, evaluate, and report changes of state or value occurring among associated points. Continue to perform associated control functions regardless of status of network.
7. Perform in stand-alone mode:

    a. Start/stop.
    b. Duty cycling.
    c. Automatic Temperature Control.

d. Demand control via a sliding window, predictive algorithm.
e. Event initiated control.
f. Calculated point.
g. Scanning and alarm processing.
h. Full direct digital control.
i. Trend logging.
j. Global communications.
k. Maintenance scheduling.

D. Global Communications:

1. Broadcast point data onto network, making information available to other system controls units.
2. Transmit input/output points onto network for use by other control units and use data from other control units.

E. Input/output Capability:

1. Discrete/digital input (contact status).
2. Discrete/digital output.
3. Analog input.
4. Analog output.
5. Pulse input (5 pulses/second minimum).
6. Pulse output (0-655 seconds in duration with 0.01-second resolution minimum).

F. Monitor, control, or address data points. Include analog inputs, analog outputs, pulse inputs, pulse outputs and discrete inputs/outputs. Furnish control units with minimum 30 percent spare capacity.

G. Point Scanning: Set scan or execution speed of each point to operator selected time from 1 to 250 seconds.

H. Upload/Download Capability: Download from or upload to operator station. Upload/Download time for entire control unit database maximum 10 seconds on hard-wired LAN or 60 seconds over voice grade phone lines.

I. Test Mode Operation: Place input/output points in test mode to allow testing and developing of control algorithms on line without disrupting field hardware and controlled environment. In test mode:

1. Inhibit scanning and calculation of input points. Issue manual control to input points (set analog or digital input point to operator determined test value) from workstation.
2. Control output points but change only database state or value; leave external field hardware unchanged.
3. Enable control-actions on output points but change only data base state or value.

J. Local display and adjustment panel: [Portable] [or] [Integral to] control-unit containing digital display, and numerical keyboard. Display and adjust:

1. Input/output point information and status.

2. Controller set points.
3. Controller tuning constants.
4. Program execution times.
5. High and low limit values.
6. Limit differential.
7. Set/display date and time.
8. Control outputs connected to the network.
9. Automatic control outputs.
10. Perform control unit diagnostic testing.

K. Points in "Test" mode.

2.3 LOCAL AREA NETWORKS (LAN):

A. Furnish communication between control units over local area network (LAN).

B. LAN Capacity: Not less than 60 stations or nodes.

C. Break in Communication Path: Alarm and automatically initiate LAN reconfiguration.

D. LAN Data Speed: Minimum 19.2 Kb.

E. Communication Techniques: Allow interface into network by multiple operation stations and by auto-answer/auto-dial modems. Support communication over high speed internet access utilizing wireless modems and routers.

F. Transmission Median: Fiber optic or single pair of solid 24 gauge twisted, shielded copper cable.

G. Network Support: Time for global point to be received by any station, less than 3 seconds. Furnish automatic reconfiguration when station is added or lost. In event transmission cable is cut, reconfigure two sections with no disruption to system's operation, without operator intervention.

2.4 LOAD CONTROL PROGRAMS

A. General: Support inch-pounds units of measurement.

B. Duty Cycling:

1. Periodically stop and start loads, based on space temperature, and according to various On/Off patterns.
2. Modify off portion of cycle based on operator specified comfort parameters. Maintain total cycle time by increasing on portion of cycle by equal quantity off portion is reduced.
3. Set and modify following parameters for each individual load.

a. Minimum and maximum off time.
b. On/Off time in one-minute increments.

c. Time period from beginning of interval until cycling of load.
d. Manually override the DDC program and place a load in an On or Off state.
e. Cooling Target Temperature and Differential.
f. Heating Target Temperature and Differential.
g. Cycle off adjustment.

C. Automatic Time Scheduling:

1. Self-contained programs for automatic start/stop/scheduling of building loads.
2. Support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary day schedules.
3. Special day?s schedule supporting up to 30 unique date/duration combinations.
4. Number of loads assigned to time program; with each load having individual time program.
5. Each load assigned at least 16 control actions for each day with 1 minute resolution.
6. Furnish the following time schedule operations:

a. Start.
b. Optimized Start.
c. Stop.
d. Optimized Stop.
e. Cycle.
f. Optimized Cycle.

7. Capable of specifying minimum of 30 holiday periods up to 100 days in length for the year.
8. Create temporary schedules.
9. Broadcast temporary "special day" date and duration.

D. Start/Stop Time Optimization:

1. Perform optimized start/stop as function of outside conditions, inside conditions, or both.
2. Adaptive and self-tuning, adjusting to changing conditions unattended.
3. For each point under control, establish and modify:

a. Occupancy period.
b. Desired temperature at beginning of occupancy period.
c. Desired temperature at end of occupancy period.

E. Night Setback/Setup Program: Reduce heating space temperature set point or raise cooling space temperature set-point during unoccupied hours; in conjunction with scheduled start/stop and optimum start/stop programs.

F. Calculated Points: Define calculations and totals computed from monitored points (analog/digital points), constants, or other calculated points.

1. Employ arithmetic, algebraic, Boolean, and special function operations.
2. Treat calculated values like any other analog value; use for any function where a "hard wired point" might be used.

G. Event Initiated Programming: Any data point capable of initiating event, causing series of controls in a sequence.

1. Define time interval between each control action between 0 to 3600 seconds.
2. Output may be analog value.
3. Provide for "skip" logic.
4. Verify completion of one action before proceeding to next action. When not verified, program capable of skipping to next action.

H. Direct Digital Control: Furnish with each control unit Direct Digital Control software so operator is capable of customizing control strategies and sequences of operation by defining appropriate control loop algorithms and choosing optimum loop parameters.

1. Control loops: Defined using "modules" are analogous to standard control devices.
2. Output: Paired or individual digital outputs for pulse width modulation, and analog outputs.
3. Firmware:

    a. PID with analog or pulse-width modulation output.
    b. Floating control with pulse-width modulated outputs.
    c. Two-position control.
    d. Primary and secondary reset schedule selector.
    e. Hi/Low signal selector.
    f. Single pole double-throw relay.
    g. Single pole double throw time delay relay with delay before break, delay before make and interval time capabilities.

4. Direct Digital Control loop: Downloaded upon creation or on operator request. On sensor failure, program executes user defined failsafe output.
5. Display: Value or state of each of lines interconnecting DDC modules.

I. Fine Tuning Direct Digital Control PID or floating loops:

1. Display information:

    a. Control loop being tuned.
    b. Input (process) variable.
    c. Output (control) variable.
    d. Set-point of loop.
    e. Proportional band.
    f. Integral (reset) Interval.
    g. Derivative (rate) Interval.

2. Display format: Graphic, with automatic scaling; with input and output variable superimposed on graph of "time" versus "variable".

2.5 HVAC CONTROL PROGRAMS

A. General:

1. Support Inch-pounds units of measurement.
2. Identify each HVAC Control system.

B. Optimal Run Time:

1. Control start-up and shutdown times of HVAC equipment for both heating and cooling.
2. Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.
3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.
4. Use outside air temperature to determine early shut down with ventilation override.
5. Analyze multiple building mass sensors to determine seasonal mode and worse case condition for each day.
6. Operator commands:

    a. Define term schedule.
    b. Add/delete fan status point.
    c. Add/delete outside air temperature point.
    d. Add/delete mass temperature point.
    e. Define heating/cooling parameters.
    f. Define mass sensor heating/cooling parameters.
    g. Lock/unlock program.
    h. Request optimal run-time control summary.
    i. Request optimal run-time mass temperature summary.
    j. Request HVAC point summary.
    k. Request HVAC saving profile summary.

7. Control Summary:

    a. HVAC Control system begin/end status.
    b. Optimal run time lock/unlock control status.
    c. Heating/cooling mode status.
    d. Optimal run time schedule.
    e. Start/Stop times.
    f. Selected mass temperature point ID.
    g. Optimal run-time system normal start-times.
    h. Occupancy and vacancy times.
    i. Optimal run time system heating/cooling mode parameters.

8. Mass temperature summary:

    a. Mass temperature point type and ID.
    b. Desired and current mass temperature values.
    c. Calculated warm-up/cool-down time for each mass temperature.
    d. Heating/cooling season limits.
    e. Break point temperature for cooling mode analysis.

9. HVAC point summary:

a. Control system identifier and status.
b. Point ID and status.
c. Outside air temperature point ID and status.
d. Mass temperature point ID and status.
e. Calculated optimal start and stop times.
f. Period start.

C. Enthalpy Switchover:

1. Calculate outside and return air enthalpy using measured temperature and relative humidity; determine energy expended and control outside and return air dampers.
2. Operator commands:

a. Add/delete fan status point.
b. Add/delete outside air temperature point.
c. Add/delete discharge controller point.
d. Define discharge controller parameters.
e. Add/delete return air temperature point.
f. Add/delete outside air dewpoint/humidity point.
g. Add/delete return air dewpoint/humidity point.
h. Add/delete damper switch.
i. Add/delete minimum outside air.
j. Add/delete atmospheric pressure.
k. Add/delete heating override switch.
l. Add/delete evaporative cooling switch.
m. Add/delete air flow rate.
n. Define enthalpy deadband.
o. Lock/unlock program.
p. Request control summary.
q. Request HVAC point summary.

3. Control summary:

a. HVAC control system begin/end status.
b. Enthalpy switchover optimal system status.
c. Optimal return time system status.
d. Current outside air enthalpy.
e. Calculated mixed air enthalpy.
f. Calculated cooling cool enthalpy using outside air.
g. Calculated cooling cool enthalpy using mixed air.
h. Calculated enthalpy difference.
i. Enthalpy switchover deadband.
j. Status of damper mode switch.

2.6 PROGRAMMING APPLICATION FEATURES

A. Alarm Messages:

1. Allow definition of minimum of 20 messages, each having minimum length of 100 characters for each individual message.
2. Assign alarm messages to system messages including point's alarm condition, point's off-normal condition, totaled point's warning limit, hardware elements advisories.
3. Output assigned alarm with "message requiring acknowledgment".
4. Operator commands include define, modify, or delete; output summary listing current alarms and assignments; output summary defining assigned points.

B. Weekly Scheduling:

1. Automatically initiate equipment or system commands, based on selected time schedule for points specified.
2. Program times for each day of week, for each point, with one minute resolution.
3. Automatically generate alarm output for points not responding to command.
4. Allow for holidays, minimum of 366 consecutive holidays.
5. Operator commands:

    a. System logs and summaries.
    b. Start of stop point.
    c. Lock or unlock control or alarm input.
    d. Add, delete, or modify analog limits and differentials.
    e. Adjust point operation position.
    f. Change point operational mode.
    g. Open or close point.
    h. Enable/disable, lock/unlock, or execute interlock sequence or computation profile.
    i. Begin or end point totals.
    j. Modify total values and limits.
    k. Access or secure point.
    l. Begin or end HVAC or load control system.
    m. Modify load parameter.
    n. Modify demand limiting and duty cycle targets.

6. Output summary: Listing of programmed function points, associated program times, and respective day of week programmed points by software groups or time of day.

C. Interlocking:

1. Permit events to occur, based on changing condition of one or more associated master points.
2. Binary contact, high/low limit of analog point or computed point capable of being used as master. Master capable of monitoring or commanding multiple slaves.
3. Operator commands:

    a. Define single master/multiple master interlock process.
    b. Define logic interlock process.
    c. Lock/unlock program.
    d. Enable/disable interlock process.
    e. Execute terminate interlock process.
    f. Request interlock type summary.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify conditioned power supply is available to control units and to operator workstation.

B. Verify field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.

3.2 INSTALLATION

A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.

B. Install software in control units and in operator workstation. Implement features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 23 09 93.

C. Install with 120 volts alternating current, 15 amp dedicated emergency power circuit to each programmable control unit.

D. Install conduit and electrical wiring in accordance Division 26.

E. Install electrical material and installation in accordance with appropriate requirements of Division 26.

3.3 MANUFACTURER'S FIELD SERVICES

A. Start and commission systems. Allow adequate time for start-up and commissioning prior to placing control systems in permanent operation.

B. Furnish service technician employed by system installer to instruct Owner's representative in operation of systems plant and equipment for 1-day period.

3.4 DEMONSTRATION AND TRAINING

A. Furnish basic operator training for 2 persons on data display, alarm and status descriptors, requesting data, execution commands and log requests. Include a minimum of 16 hours instructor time. Furnish training on site.

B. Demonstrate complete and operating system to Owner.

3.5 SCHEDULES

A. Alarm Schedule:

1. Types:

a. A1: High Limit.
b. A2: Low Limit.
c. A3: Run Time.
d. A4: Maintenance.
e. A5: Status.
f. A6: Override.
g. A7: Freeze.
h. A8: Low Pressure.

END OF SECTION 23 09 23

SECTION 23 09 93 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes sequence of operation for:

1. Exhaust fans.
2. Heating Coils.
3. Humidifiers.
4. Water Source Heat Pumps.
5. Packaged Rooftop Hospital-grade AC Units.
6. Indoor Energy Recovery Ventilator and Conditioning Unit.

B. Related Sections:

1. Section 23 09 23 - Direct-Digital Control System for HVAC: For equipment, devices, system components, and software to implement sequences of operation.

1.2 SUBMITTALS

A. Shop Drawings: Indicate mechanical system controlled and control system components.

1. Label with settings, adjustable range of control and limits. Submit written description of control sequence.
2. Submit flow diagrams for each control system, graphically depicting control logic.
3. Submit draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.

1.3 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of components and set points of controls, including changes to sequences made after submission of shop drawings.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 EXHAUST FANS

A. Fan shall operate continuously.

B. When fan is operating, the motorized inlet damper is to be opened.

C. Fan deactivation shall sound a local alarm.

3.2 EXCESS PRESSURE CONTROLS

A. Maintain constant pressure differential downstream of AC-R by varying fan motor speed through variable speed drive control.

3.3 HUMIDIFIERS (H-1)

A. When supply fan is running and airflow switch proves airflow and there is water in humidifier sump, humidistat located in in the space modulates electric humidifier output to maintain the room humidity at 35% (adj.).

3.4 HEATING COILS (HC-4, HC-5, HC-6)

A. Dual temperature thermostat set at 72F (adjustable) maintains constant space temperature during day and 68 degrees F at night. Thermostat modulates two- way control heating valve with spring range of 3 to 7 psig.

3.5 ROOF-MOUNTED AIR-COOLED HEAT PUMP (AC-R)

A. Unit shall start/stop in response to the space occupancy timeclock (7-day programmable with override switch).

B. If space temperatures fall below setpoint, the unit shall be energized in night-setback mode. Unit shall operate as 100% recirculation and only the heating coil valves shall be modulated to maintain minimum space temperatures. Any of the three (3) space temperature sensors can enable night-setback operation.

C. When operational, unit shall maintain a set discharge temperature (as measured by a discharge duct thermostat) of 55 degrees F (adj.). Discharge setpoint will also be modified as per controls per HC-1, HC-2 and HC-3 (see Article 3.7). When operating in night setback mode, the discharge thermostat shall be overridden.

D. Unit internal controls shall enable/disable modulate the unit cooling as required to maintain the discharge air setpoint temperature.

E. Unit internal controls shall modulate the dampers on the return, spill and outside air to provide minimum outside air or air side economizer operation as required.

F. Unit shall be provided with static pressure sensors across the inlet and discharge air filters to alert operators when filters become dirty.

G. Unit supply air fan speed shall be mounted via a discharge air pressure stat to maintain supply air flow (CFM).

H. Unit shall be provided with a duct-mounted smoke detector to disable the unit and ready an alarm to the building FA system if smoke is detected in the unit.

3.6 AIR-COOLED OUTSIDE AIR ENERGY RECOVERY UNIT (ERU-1)

A. Unit shall start/stop in response to the space occupancy time clock

B. When operating, unit internal controls shall cycle cooling/heating/economizer operations as required to provide 72 degrees F. discharge air to the AC units.

3.7 HOT WATER COILS (HC-1, HC-2, HC-3)

A. Duct-mounted coils shall modulate to maintain minimum space temperatures in the wall-mounted thermostats.

B. While in unoccupied mode, a drop in space temperature below setpoint, unit AC-R shall be enabled in night setback mode.

C. If during occupied mode, all three coils call for heating, the discharge air setpoint temperature for AC-R shall be increased until at least one coil is inactive.

3.8 HEAT PUMP (AC-1, AC-2, AC-3)

A. Unit shall start/stop in response to the space occupancy time clock.

B. Unit capacity shall be mounted (cooling) in response to the space thermostat.

C. If the space temperature falls below setpoint, cooling shall be disabled and the duct hot water coil enabled (see Article 3.4).

3.9 UNIT SENSORS

A. Should any unit’s internal safeties be activated (i.e., high refrigerant pressure, water, leak, etc.), the unit shall be disabled and a local alarm sounded.

END OF SECTION 23 09 93

SECTION 23 21 16 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pressure gages.
2. Pressure gage taps.
3. Thermometers.
4. Thermometer supports.
5. Test plugs.
6. Flexible connectors.
7. Air vents.

B. Related Sections:

1. Section 23 05 03 - Pipes and Tubes for HVAC Piping and Equipment: Product and installation requirements for piping materials applying to various system types.

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 E1 - Standard Specification for ASTM Thermometers.
2. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers.

1.3 PERFORMANCE REQUIREMENTS

A. Flexible Connectors: Provide at or near motorized equipment where piping configuration does not absorb vibration.

1.4 SUBMITTALS

A. Product Data: Submit for manufactured products and assemblies used in this Project.

1. Manufacturer's data 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.

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

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

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Accept piping specialties on site in shipping containers with labeling in place. Inspect for damage.

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. 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 EXTRA MATERIALS

A. Section 01 70 00 - Execution and Closeout Requirements: Spare parts and maintenance products.

B. Furnish two (2) [pressure gages with pulsation damper] [dial thermometers]

PART 2 - PRODUCTS

2.1 PRESSURE GAGES

A. Manufacturers:

1. Hayward Flow Control.
2. WATTS.
3. Zurn Industries, LLC.

B. Gage: ASME B40.1, with bourdon tube, rotary brass movement, brass socket, front calibration adjustment, black scale on white background.

1. Case: Cast aluminum and Fiberglass reinforced polypropylene.
2. Bourdon Tube: Brass.
3. Dial Size: 2 inch diameter.
4. Mid-Scale Accuracy: two percent.
5. Scale: Psi.

2.2 PRESSURE GAGE TAPS

A. Manufacturers:

1. Hayward Flow Control.

B. Needle Valve: Brass, 1/4 inch NPT for minimum 300 psi.

C. Ball Valve: Brass, 1/4 inch NPT for 250 psi.

D. Pulsation Damper: Pressure snubber, brass with 1/4 inch NPT connections.

E. Siphon: Brass, 1/4 inch NPT angle or straight pattern.

2.3 STEM TYPE THERMOMETERS

A. Manufacturers:

1. KOBOLD Instruments, Inc. - USA.
2. Marsh Bellofram.
3. Weiss Instruments, Inc.

B. Thermometer: ASTM E1, red appearing mercury, lens front tube, cast aluminum case with enamel finish.

1. Size: 7-inch scale.
2. Window: Clear glass.
3. Stem: Brass, 3/4 inch NPT, 3-1/2 inch long.

4. Accuracy: ASTM E77 2 percent.
5. Calibration: Degrees F.

C. Thermometer: ASTM E1, adjustable angle, red appearing mercury, lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device.

1. Size: 7 inch scale.
2. Window: Clear glass.
3. Stem: Brass, 3/4 inch NPT, [**3-1/2 inch**] long.
4. Accuracy: ASTM E77 2 percent.
5. Calibration: Degrees F.

2.4 THERMOMETER SUPPORTS

A. Socket: Brass separable sockets for thermometer stems with or without extensions.

B. Flange: 3 inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.5 TEST PLUGS

A. Manufacturers:

1. IPS Corporation.
2. Oatey.
3. Petersen Products Co.
4. WATTS.
5. Zurn Industries, LLC.

B. 1/4 inch NPT or 1/2 inch NPT brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with:

1. Neoprene core for temperatures up to 200 degrees F.
2. Nordel core for temperatures up to 350 degrees F.
3. Viton core for temperatures up to 400 degrees F.

C. Test Kit:

1. Carrying case, internally padded and fitted containing:

a. Two (2) 3-1/2-inch diameter pressure gages.

b. Two gage adapters with 1/8 inch probes.
c. Two 1-inch dial thermometers.

2.6 FLEXIBLE CONNECTORS

A. Manufacturers:

1. Flex-Hose Co., Inc.
2. Flex-Weld, Inc.
3. Hyspan Precision Products, Inc.
4. Twin City Hose, Inc.
5. US Hose Corporation; Amnitec Group.

B. Corrugated stainless steel hose with single layer of stainless steel exterior braiding, minimum 9 inches long with copper tube ends; for maximum working pressure 300 psig.

2.7 AIR VENTS

A. Manufacturers:

1. AMTROL, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett; a Xylem brand.
4. Hoffman Specialty.
5. Taco Comfort Solutions.

B. Manual Type: Short vertical sections of 2 inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.

C. Float Type:

1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

D. Washer Type:

1. Brass with hydroscopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring-loaded ball check valve.

PART 3 - EXECUTION

3.1 INSTALLATION - THERMOMETERS AND GAGES

A. Install one pressure gage for each unit, locate taps before strainers and on inlet and discharge of unit; pipe to gage.

B. Install gage taps in piping

C. Install pressure gages with pulsation dampers. Provide needle valve to isolate each gage. Extend nipples to allow clearance from insulation.

D. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inches for installation of thermometer sockets. Allow clearance from insulation.

E. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets.

F. Coil and conceal excess capillary on remote element instruments.

G. Provide instruments with scale ranges selected according to service with largest appropriate scale.

H. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

I. Adjust gages and thermometers to final angle, clean windows and lenses, and calibrate to zero.

3.2 INSTALLATION - HYDRONIC PIPING SPECIALTIES

A. Locate test plugs [adjacent to thermometers and thermometer sockets] [adjacent to pressure gages and pressure gage taps] [adjacent to pressure gages and pressure gage taps] [adjacent to control device sockets].

B. Where large air quantities accumulate, provide enlarged air collection standpipes.

C. Install manual air vents at system high points.

D. For automatic air vents in ceiling spaces or other concealed locations, install vent tubing to nearest drain.

E. Provide drain and hose connection with valve on strainer blow down connection.

3.3 PROTECTION OF INSTALLED CONSTRUCTION

A. Do not install hydronic pressure gauges until after systems are pressure tested.

END OF SECTION 23 21 16

SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Refrigerant piping.
2. Pipe hangers and supports.

B. Related Sections:

1. Section 23 05 03 - Pipes and Tubes for HVAC Piping and Equipment: Piping materials for refrigerant systems.
2. Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment: Product requirements for pipe hangers and supports, sleeves, for placement by this section.
3. Section 23 05 53 - Identification for HVAC Piping and Equipment: Product requirements for pipe identification for placement by this section.
4. Section 23 07 00 - HVAC Insulation: Product requirements for Piping Insulation for placement by this section.

1.2 REFERENCES

A. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 15 - Safety Code for Mechanical Refrigeration.

B. American Society of Mechanical Engineers:

1. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
2. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes.
3. ASME B31.5 - Refrigeration Piping.
4. ASME Section VIII - Boiler and Pressure Vessel Code - Pressure Vessels.

C. ASTM International:

1. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
2. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
3. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
4. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric).
5. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
6. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.

7. ASTM B749 - Standard Specification for Lead and Lead Alloy Strip, Sheet, and Plate Products.

D. American Welding Society:

1. AWS A5.8 - Specification for Filler Metals for Brazing and Braze Welding.

1.3 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified, provide compatible system components and joints. Use non-conducting dielectric connections when joining dissimilar metals in systems.

B. Provide flanges, unions, or couplings at locations requiring servicing. Use unions, flanges, or couplings downstream of valves and at equipment connections. Do not use direct welded or threaded connections to valves or equipment.

C. Provide pipe hangers and supports in accordance with ASME B31.5.

1.4 SUBMITTALS

A. Shop Drawings: Indicate layout of refrigeration piping system, including equipment, critical dimensions, and sizes.

B. Product Data:

1. Piping: Submit data on pipe materials, fittings, and accessories.
2. Hangers and Supports: Submit manufacturer's catalog information including load capacity.

C. Test Reports: Indicate results of refrigerant leak test.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with ASME B31.5 code for installation of refrigerant piping systems.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience.

B. Fabricator or Installer: Company specializing in performing Work of this section with minimum three years' experience approved by manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Dehydrate and charge refrigeration components including piping and receivers, seal prior to shipment. Maintain seal until connected into system.

B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the Work, and isolating parts of completed system.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.1 REFRIGERANT PIPING

A. Copper Tubing: ASTM B280, drawn.

1. Fittings: ASME B16.22 wrought copper.
2. Joints: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 degrees F.

B. Copper Tubing to 7/8 inch OD: ASTM B88, Type K, annealed.

1. Fittings: ASME B16.26 cast copper, compression type.
2. Joints: Flared.

2.2 UNIONS, FLANGES, AND COUPLINGS

A. 2 inches and Smaller:

1. Ferrous Piping: 150 psig malleable iron, threaded.
2. Copper Pipe: Bronze, soldered joints.

2.3 PIPE HANGERS AND SUPPORTS

A. Manufacturers:

1. CADDY; nVent.
2. Carpenter & Paterson, Inc.
3. Empire Industries, Inc.

4. Globe Pipe Hanger Products Incorporated.
5. Haydon Corporation.
6. Hilti, Inc.
7. NIBCO INC.
8. PHD Manufacturing, Inc.
9. PHS Industries, Inc.
10. Unitron Product, Inc. / US-Strut.

B. Conform to ASME B31.5.

C. Copper Pipe Support: Carbon steel rings, adjustable, copper plated.

D. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

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

F. Sheet Lead: ASTM B749, [2.5 lb/sq. ft.] [0.039] inch thick.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.2 INSTALLATION - PIPE HANGERS AND SUPPORTS

A. Install hangers and supports in accordance with ASME B31.5.

B. Support horizontal piping hangers as scheduled.

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

D. Place hangers within 12 inches of each horizontal elbow.

E. Install hangers to allow 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.

F. Where installing several pipes in parallel and at same elevation, provide multiple pipe hangers or trapeze hangers.

G. Provide copper plated hangers and supports for copper piping.

H. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.

I. Install pipe hangers and supports in accordance with Section 23 05 29.

3.3 INSTALLATION - ABOVE GROUND PIPING SYSTEMS

A. Route piping parallel to building structure and maintain gradient.

B. Install piping to conserve building space, and not interfere with use of space.

C. Group piping whenever practical at common elevations.

D. Install pipe identification in accordance with Section 23 05 53.

E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

F. Arrange refrigerant piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.

G. Flood refrigerant piping system with nitrogen when brazing.

H. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

I. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.

J. Install valves with stems upright or horizontal, not inverted.

K. Insulate piping.

L. Fully charge completed system with refrigerant after testing.

M. Follow ASHRAE 15 procedures for charging and purging of systems and for disposal of refrigerant.

N. Install refrigerant piping in accordance with ASME B31.5.

3.4 FIELD QUALITY CONTROL

A. Test refrigeration system in accordance with ASME B31.5.

B. Pressure test refrigeration system with dry nitrogen to 200 psig. [Perform final tests at 27 inches vacuum and 200 psig using [halide torch.] [electronic leak detector.]]

C. Repair leaks.

D. Retest until no leaks are detected.

3.5 SCHEDULES

A. Copper Tube Hanger Spacing:

1. Pipe Size 1/2 Inch:

a. Maximum Hanger Spacing: 5 feet.
b. Hanger Rod Diameter: 3/8 inch.

2. Pipe Size 3/4 Inch:

a. Maximum Hanger Spacing: 5 feet.
b. Hanger Rod Diameter: 3/8 inch.

3. Pipe Size 1 Inch:

a. Maximum Hanger Spacing: 6 feet.
b. Hanger Rod Diameter: 3/8 inch.

END OF SECTION 23 23 00

SECTION 23 31 00 - HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Duct materials.
2. Flexible ducts.
3. Single-wall, spiral round ducts.
4. Casings.
5. Ductwork fabrication.
6. Duct cleaning.

B. Related Requirements:

1. Section 23 33 00 - Air Duct Accessories: Requirements for duct accessories as specified in this Section.

1.2 REFERENCE STANDARDS

A. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE Handbook - Fundamentals.

B. American Welding Society:

1. AWS D1.1 - Structural Welding Code - Steel.
2. AWS D1.1M - Structural Welding Code - Steel.
3. AWS D1.2 - Structural Welding Code - Aluminum.
4. AWS D1.2M - Structural Welding Code - Aluminum.
5. AWS D9.1 - Sheet Metal Welding Code.
6. AWS D9.1M - Sheet Metal Welding Code.

C. ASTM International:

1. ASTM A36 - Standard Specification for Carbon Structural Steel.
2. ASTM A36M - Standard Specification for Carbon Structural Steel.
3. ASTM A90 - Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
4. ASTM A90M - Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
5. ASTM A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
6. ASTM A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

7. ASTM A568 - Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
8. ASTM A568M - Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
9. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
10. ASTM A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
11. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
12. ASTM A1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
13. ASTM A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
14. ASTM A1011 - 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.
15. ASTM A1011M - 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.
16. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
17. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
18. ASTM C14 - Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.
19. ASTM C14M - Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe (Metric).
20. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
21. ASTM C443M - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric).
22. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

D. International Code Council:

1. International Energy Conservation Code (IECC).
2. International Mechanical Code (IMC).

E. NFPA:

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

F. Sheet Metal and Air Conditioning Contractors' National Association:

1. SMACNA 016 - HVAC Air Duct Leakage Test Manual.
2. SMACNA 1767 - Kitchen Ventilation Systems and Food Service Equipment Guidelines.

3. SMACNA 1884 - Fibrous Glass Duct Construction Standards.
4. SMACNA 1966 - HVAC Duct Construction Standards - Metal and Flexible.

1.3 SUBMITTALS

A. Shop Drawings:

1. Submit duct fabrication drawings, drawn to scale not smaller than 3/8 inch equals 1 foot, on sheets same size as Contract Drawings, indicating following:

    a. Fabrication, assembly, and installation details, including plans, elevations, sections, details of components, and attachments to other Work.
    b. Duct layout that further indicates pressure classifications and sizes in plan view; exhaust duct systems that further indicate classification of materials handled as specified in this Section.
    c. Fittings.
    d. Reinforcing details and spacing.
    e. Seam and joint construction details.
    f. Penetrations through fire-rated and other walls.
    g. Terminal unit, coil, and humidifier installations.
    h. Hangers and supports, including methods for vibration isolation and building and duct attachment.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents:

1. Record actual locations of ducts and duct fittings.
2. Record changes in fitting location and type.
3. Show additional fittings used.

1.5 QUALITY ASSURANCE

A. Perform Work according to SMACNA 1884 and 1966.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three (3) years' experience.

B. Installer: Company specializing in performing Work of this Section with minimum three (3) years' experience.

C. Welders: AWS qualified within previous 12 months for employed weld types.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.

B. Store materials according to manufacturer instructions.

C. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Provide additional protection according to manufacturer instructions.

1.8 AMBIENT CONDITIONS

A. Minimum Conditions: Do not install duct sealant when temperatures are less than those recommended by sealant manufacturer.

B. Subsequent Conditions: Maintain temperatures during and after installation of duct sealant.

1.9 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 DUCTS

A. Performance and Design Criteria:

1. Variation of duct configuration or sizes other than those of equivalent or lower loss coefficient is not permitted except by written permission of Architect/Engineer.

B. Materials:

C. Galvanized-Steel Ducts:

1. Material: ASTM A653 galvanized-steel sheet.
2. Quality: Lock forming.
3. Finish: G60 zinc coating according to ASTM A90.

D. Aluminum Ducts:

1. Material: ASTM B209 aluminum sheet Alloy 3003-H14.

2. Connectors and Bar Stock: Aluminum Alloy 6061-T6 or equivalent strength.

E. Stainless-Steel Ducts: Comply with ASTM A240, Type 304.

F. Fasteners: Rivets, bolts, or sheet metal screws.

G. Hanger Rod:

1. Material: Galvanized steel.
2. Comply with ASTM A36.
3. Type: Threaded continuously.

2.2 FLEXIBLE DUCTS

A. Manufacturers:

1. Hart & Cooley Inc.

B. Description:

1. Two-ply vinyl film supported by helical-wound spring steel wire.
2. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
3. Maximum Velocity: 4,000 fpm.
4. Temperature Range: Minus 10 to plus 160 degrees F.

2.3 SINGLE-WALL, SPIRAL ROUND DUCTS

A. Manufacturers:

1. McGill AirFlow LLC.
2. Spiro Metal Inc.
3. Substitutions: As specified in Section 01 60 00 - Product Requirements Not permitted.

B. Description:

1. UL 181, Class 1, round spiral lockseam duct.
2. Material: Galvanized steel.

C. Minimum Duct Wall Thicknesses:

1. Diameter 2 to 14 Inches: 26 gage.

D. Minimum Fittings Wall Thicknesses:

1. Diameter 2 to 14 Inches: 24 gage.

2.4 CASINGS

A. Fabricate casings according to SMACNA 1966 and construct for indicated operating pressures.

B. Doors:

1. Reinforce access door frames with steel angles tied to horizontal and vertical plenum supporting angles.
2. Furnish hinged access doors where indicated or required for access to equipment for cleaning and inspection.

2.5 FABRICATION

A. Rectangular Ducts:

1. According to SMACNA 1966 [and as indicated on Drawings].
2. Provide duct material, gages, reinforcing, and sealing for indicated operating pressures.

B. Tees, Bends, and Elbows:

1. Minimum Radius:

a. 1-1/2 times centerline duct width.
b. If not possible or if rectangular elbows are used, provide [airfoil] turning vanes.

2. If acoustical lining is indicated, furnish turning vanes of perforated metal with glass-fiber insulation.

C. Divergence:

1. Increase duct sizes gradually, not exceeding 15 degrees of divergence wherever possible.
2. Upstream of Equipment: Maximum 30 degrees.
3. Downstream of Equipment: Maximum 45 degrees.

D. Welding:

1. Continuously Welded Round and Oval Duct Fittings: Two gages heavier than duct gages according to SMACNA 1966.
2. Cemented Slip Joints:

a. Minimum 4 inches.
b. Brazed or electric welded.

3. Prime coat welded joints.

E. Takeoffs:

1. Provide standard 45-degree lateral wye takeoffs.
2. If not possible due to space limitations, provide 90-degree conical tee connections.

F. Sealing:

1. Seal joints between duct sections and duct seams with welds, gaskets, mastic adhesives, mastic plus embedded fabric systems, or tape.
2. Sealants, Mastics, and Tapes: Comply with UL 181A and provide products bearing appropriate UL 181A markings.

2.6 ACCESSORIES

A. Hangers and Supports:

1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
2. Strap and Rod Sizes:

   a. Comply with SMACNA 1966.
   b. Glass-Fiber-Reinforced Ducts: Comply with SMACNA 1884.

3. Trapeze and Riser Supports:

   a. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   b. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
   c. Supports for Aluminum Ducts: Aluminum or galvanized steel, coated with zinc chromate.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify sizes of equipment connections before fabricating transitions.

3.2 PREPARATION

A. Obtain manufacturer's inspection and acceptance of fabrication and installation at beginning of installation.

B. Install temporary closures of metal or taped PE on open ductwork to prevent construction dust from entering ductwork system.

3.3 INSTALLATION

A. Install and seal ducts according to SMACNA 1966.

B. Insulated Flexible Duct Fittings:

1. Join each flexible duct section to main trunk duct through sheet metal fittings.
2. Material: Galvanized steel.

3. Equip fittings with factory-installed volume damper having positive locking regulator.
4. Provide insulation guard with fittings installed in lined ductwork.

C. Use crimp joints with or without bead or beaded sleeve couplings for joining round duct sizes 8 inches and smaller.

D. Hanger and Supports:

1. Fabricate and support ducts according to SMACNA [1884] [and] [1966].
2. Threaded Rods: Provide double nuts and lock washers.
3. Building Attachments:

    a. Provide concrete inserts or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
    b. If possible, install concrete inserts before placing concrete.
    c. Powder-Actuated Concrete Fasteners:

        1) Use only for slabs more than 4 inches thick.
        2) Install after concrete is placed and completely cured.
        3) Do not use powder-actuated concrete fasteners for seismic restraints.

4. Hanger Spacing:

    a. Comply with SMACNA [1884] [and] [1966].
    b. Install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
    c. Extend strap supports down both sides of ducts and turn under bottom at least 1 inch.
    d. Secure hanger to sides and bottom of ducts with sheet metal screws.

5. Hangers Exposed to View: Provide threaded rod and angle or channel supports.
6. Vertical Ducts:

    a. Support with steel angles or channel secured to sides of duct with welds, bolts, sheet metal screws, or blind rivets.
    b. Support at each floor and at maximum intervals of 16 feet.

7. Upper Attachments:

    a. Attach to structures.
    b. Selection and Sizing: Provide pull-out, tension, and shear capacities as required for supported loads and building materials.

8. Penetrations:

    a. Avoid penetrations of ducts with hanger rods.
    b. If unavoidable, provide airtight rubber grommets at penetrations.

E. Connect flexible ducts to metal ducts with draw bands plus sheet metal screw].

F. Plenum Doors:

1. Location: 6 to 12 inches above floor.
2. Arrange door swing such that fan static pressure holds door in closed position.

G. Outdoor Ductwork: Protect ductwork and ductwork supports, linings, and coverings from weather.

H. Exhaust Outlet Locations:

1. Minimum Distance from Property Lines: 3 feet.
2. Minimum Distance from Building Openings: 3 feet.
3. Minimum Distance from Outside Air Intakes: 10 feet or 25 feet. Refer to Plans.

I. Interface with Other Work:

1. Install openings in ductwork as required to accommodate thermometers and controllers.
2. Install pitot tube openings for testing of systems, complete with metal can with spring device or screw to prevent air leakage.
3. If openings are provided in insulated ductwork, install insulation material inside metal ring.
4. Connect diffusers or light troffer boots to low-pressure ducts.

3.4 FIELD QUALITY CONTROL

A. Testing:

1. Ductwork Designed for 3-Inch wg above Ambient Pressure:

a. Pressure test minimum 25 percent of ductwork after duct cleaning but before duct insulation is applied or ductwork is concealed.
b. Comply with SMACNA 016.
c. Maximum Allowable Leakage: According to IECC.

3.5 CLEANING

A. Clean duct system and force air at high velocity through duct to remove accumulated dust.

B. To obtain sufficient airflow, clean one half of system completely before proceeding to other half.

C. Vacuuming:

1. Clean duct systems with high-power vacuum machines.
2. Install access openings into ductwork for cleaning purposes.

D. Protect sensitive equipment with temporary filters or bypass during cleaning.

3.6 ATTACHMENTS

A. Ductwork Material Schedule:

1. Supply - Heating Systems: Steel, aluminum.
2. Supply - Systems with Cooling Coils: Steel, aluminum.
3. Return and Relief : Steel or aluminum.
4. General Exhaust: Steel or aluminum.
5. Humidifier Duct: Stainless steel or aluminum.
6. Outside Air Intake: Steel.

B. Ductwork Pressure Class Schedule:

1. Constant Volume Supply: 2-inch wg, regardless of velocity.
2. Supply - Heating Systems: 2-inch wg.
3. Supply - Systems with Cooling Coils: 1/2-inch wg.

END OF SECTION 23 31 00

SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Combination fire-and-smoke dampers.
2. Duct access doors.
3. Volume control dampers.
4. Flexible duct connections.
5. Duct test holes.
6. Static pressure gages.

B. Related Sections:

1. Section 23 09 00 - Instrumentation and Control for HVAC: Execution and Product requirements for connection and control of Combination Smoke and Fire Dampers for placement by this section.
2. Section 23 09 23 - Direct-Digital Control System for HVAC: Execution and Product requirements for connection and control of Combination Smoke and Fire Dampers for placement by this section.
3. Section 23 31 00 - HVAC Ducts and Casings: Requirements for duct construction and pressure classifications.

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.

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.

1.3 SUBMITTALS

A. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers duct access doors and duct test holes.

B. Product Data: Submit data for shop fabricated assemblies and hardware used.

C. 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.

D. Product Data: For combination fire and smoke dampers submit the following:

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

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

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

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of access doors.

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 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.

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.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.9 COORDINATION

A. Coordinate Work where appropriate with building control Work.

PART 2 - PRODUCTS

2.1 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers:

1. Carnes Company.
2. Cesco Products; a division of MESTEK, Inc.
3. Greenheck Fan Corporation.
4. Lloyd Industries, Inc.
5. Nailor Industries Inc.
6. Ruskin Company.

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

C. Fire Resistance: 1-1/2 hours.

D. Leakage Rating: Class II, maximum of 20 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. Release Device: Close in controlled manner and lock damper through actuator closure spring.

L. Actuator:

1. Type: Electric 24 volt, 60 hertz, 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.

2.2 DUCT ACCESS DOORS

A. Manufacturers:

1. ACUDOR Products, Inc.
2. Ductmate Industries, Inc.
3. Duro Dyne Inc.
4. Kees, Inc.
5. Lane-Aire Manufacturing Corp.
6. McGill AirFlow LLC.
7. Nailor Industries Inc.
8. Nelson Industrial Inc.
9. Ruskin Company.

B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and.

C. 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. Less than 12 inches square, secure with sash locks.
2. Up to 18 inches Square: Furnish two hinges and two sash locks.
3. Compression Latch: Model _____ Manufactured by _____.
4. Hinge: Model _____ Manufactured by _____.
5. Access panels with sheet metal screw fasteners are not acceptable.

2.3 VOLUME CONTROL DAMPERS

A. Manufacturers:

1. Air Balance; a division of MESTEK, Inc.
2. Carnes Company.
3. McGill AirFlow LLC.
4. Nailor Industries Inc.
5. Ruskin Company.

B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

C. 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 [single] [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.

D. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized frame channel with suitable hardware.

E. End Bearings: Except in round ductwork 12 inches and smaller, furnish end bearings. On multiple blade dampers, furnish oil-impregnated nylon or sintered bronze bearings. Furnish closed end bearings on ducts having pressure classification over 2 inches wg.

F. Quadrants:

1. Furnish locking, indicating quadrant regulators on single and multi-blade dampers.
2. On insulated ducts mount quadrant regulators on standoff mounting brackets, bases, or adapters.
3. Where rod lengths exceed 30 inches furnish regulator at both ends.

2.4 FLEXIBLE DUCT CONNECTIONS

A. Manufacturers:

1. Duro Dyne Inc.
2. Flexmaster U.S.A., Inc.
3. Hart & Cooley Inc.
4. Labconco Corporation.

B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

C. 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, 24 gage galvanized steel.

2.5 DIAL THERMOMETERS

A. Manufacturers:

1. Ashcroft Inc.
2. MEPCO (Marshall Engineered Products Co.).

B. Thermometer: ASTM E1, stainless steel case, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.

1. Size: 2 inch diameter dial.
2. Lens: Clear glass.
3. Accuracy: 1 percent.
4. Calibration: Degrees F.

2.6 STATIC PRESSURE GAGES

A. Manufacturers:

1. Ashcroft Inc.
2. Dwyer Instruments, Inc.

B. Dial Gages: 3-1/2 inch diameter dial in metal case, diaphragm actuated, black figures on white background, front calibration adjustment, 2 percent of full scale accuracy.

C. Inclined Manometer: Plastic with red liquid on white background with black figures, front calibration adjustment, 3 percent of full scale accuracy.

D. Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4 inch diameter tubing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify rated walls are ready for fire damper installation.

B. Verify ducts and equipment installation are ready for accessories.

C. 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:

1. Upstream of each reheat coil.
2. Before and after each duct mounted filter.
3. Before and after each duct mounted coil.
4. Before and after each automatic control damper.
5. Before and after each combination fire and smoke damper.
6. Downstream of each VAV box.
7. Install at locations for cleaning kitchen exhaust ductwork in accordance with NFPA 96.

C. Access Door Sizes: Install minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated on Drawings. Review locations prior to fabrication.

1. Mark access doors for fire and smoke dampers on outside surface, with minimum 1/2 inch high letters reading: FIRE/SMOKE DAMPER, SMOKE DAMPER, OR FIRE DAMPER.

D. Install temporary duct test holes and required for testing and balancing purposes. Cut or drill in ducts. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

E. Combination fire 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 INSTALLATION - THERMOMETERS

A. Install thermometers in air duct systems on flanges.

B. Where thermometers are provided on local panels, duct mounted thermometers are not required.

C. Locate duct-mounted thermometers minimum 10 feet downstream of mixing-dampers, coils, or other devices causing air turbulence.

D. Install static pressure gages to measure across filters and filter banks, (inlet to outlet). On multiple banks, provide manifold and single gage.

E. Provide instruments with scale ranges selected according to service with largest appropriate scale.

F. Install thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

G. Adjust thermometers to final angle, clean windows and lenses, and calibrate to zero.

END OF SECTION 23 33 00

SECTION 23 34 00 - HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Downblast centrifugal roof fans.

B. Related Sections:

1. Section 23 05 13 - Common Motor Requirements for HVAC Equipment: Product requirements for motors for placement by this section.
2. Section 23 07 00s - HVAC Insulation: Product requirements for power ventilators for placement by this section.
3. Section 23 09 00 - Instrumentation and Control for HVAC: Product requirements for control components to interface with fans.
4. Section 23 09 23 - Direct-Digital Control System for HVAC: Controls remote from unit.
5. Section 23 31 00 - HVAC Ducts and Casings: Product requirements for hangers for placement by this section.
6. Section 23 33 00 - Air Duct Accessories: Product requirements for duct accessories for placement by this section.

1.2 REFERENCES

A. American Bearing Manufacturers Association:

1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. Air Movement and Control Association International, Inc.:

1. AMCA 99 - Standards Handbook.
2. AMCA 204 - Balance Quality and Vibration Levels for Fans.
3. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
4. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
5. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

C. National Electrical Manufacturers Association:

1. NEMA MG 1 - Motors and Generators.
2. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

D. Underwriters Laboratories Inc.:

1. UL 705 - Power Ventilators.

1.3 SUBMITTALS

A. Product Data: Submit data on each type of fan and include accessories, fan curves with specified operating point plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, electrical characteristics and connection requirements.

1.4 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300,and bear AMCA Certified Sound Rating Seal.

C. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.

D. Balance Quality: Conform to AMCA 204.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three (3) years' experience.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect motors, shafts, and bearings from weather and construction dust.

1.7 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.8 MAINTENANCE SERVICE

A. Furnish service and maintenance of fans for one year from Date of Substantial Completion.

B. Examine components semi-monthly bi-monthly. Clean, adjust, and lubricate equipment.

C. Include systematic examination, adjustment, and lubrication of fans, and controls checkout and adjustments. Repair or replace parts in accordance with manufacturer's operating and maintenance data. Use parts produced by manufacturer of original equipment.

D. Perform work without removing fans from service during building normal occupied hours.

PART 2 - PRODUCTS

2.1 DOWNBLAST CENTRIFUGAL ROOF FANS

A. Manufacturers:

1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. PennBarry.

B. Fan Unit: Downblast type. V-belt or direct drive, with fiberglass reinforced plastic housing; resilient mounted motor; aluminum wire bird screen; square base to suit roof curb with continuous curb gaskets.

C. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

D. Motor: Class 1, Group D, explosion proof.

E. Roof Curb: 16 inch high self-flashing of aluminum construction with continuously welded seams, built-in cant strips, 1 inch insulation and curb bottom, hinged curb adapter, and factory installed nailer strip.

F. Disconnect Switch: Factory wired, non-fusible, in fan housing for thermal overload protected motor, NEMA 250 Type 4 enclosure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify roof curbs are installed and dimensions are as shown on shop drawings.

3.2 PREPARATION

A. Furnish roof curbs for installation.

3.3 INSTALLATION

A. Secure roof fans with aluminum lag screws to roof curb.

B. Install backdraft dampers on inlet to roof exhaust fans.

C. Install safety screen where inlet or outlet is exposed.

D. Pipe scroll drains to nearest floor drain.

3.4 DEMONSTRATION

A. Demonstrate fan operation and maintenance procedures.

3.5 PROTECTION OF FINISHED WORK

A. Do not operate fans for until ductwork is clean, filters in place, bearings lubricated, and fan has been test run under observation.

END OF SECTION 23 34 00

SECTION 23 37 00 - AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Diffusers.
2. Registers.
3. Grilles.
4. Goosenecks.

B. Related Sections:

1. Section 23 33 00 - Air Duct Accessories: Volume dampers for inlets and outlets.

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. Section 01 33 00 - Submittal Procedures: Submittal procedures.

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. Samples: Submit two (2) of each required air outlet and inlet type.

D. Test Reports: Rating of air outlet and inlet performance.

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

1.4 CLOSEOUT SUBMITTALS

A. Section 01 70 00 - Execution and Closeout Requirements: Closeout procedures.

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 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience.

PART 2 - PRODUCTS

2.1 RECTANGULAR CEILING DIFFUSERS

A. Manufacturers:

1. Anemostat Products; a Mestek company.
2. Nailor Industries Inc.
3. Price Industries.
4. Titus; brand of Johnson Controls International plc, Global Products.

B. Type: Square, adjustable pattern, stamped, multi-core diffuser to discharge air in one way, two-way, three-way, four-way pattern with sector baffles where indicated.

C. Frame: Inverted T-bar type. In plaster ceilings, furnish plaster frame and ceiling frame.

D. Fabrication: Aluminum with baked enamel finish.

E. Accessories: Radial opposed-blade damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

2.2 CEILING SLOT DIFFUSERS

A. Manufacturers:

1. Anemostat Products; a Mestek company.
2. Price Industries.
3. Titus; brand of Johnson Controls International plc, Global Products.

B. Type: Continuous 1 inch wide slot, or two slots wide, with adjustable vanes for vertical discharge.

C. Fabrication: Aluminum extrusions with factory baked enamel finish, color to be selected.

D. Frame: 1 inch margin with support clips for T bar mounting and gasket mitered end border. open end construction or end cap.

E. Plenum: Integral, galvanized steel, non-insulated.

2.3 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

A. Manufacturers:

1. Nailor Industries Inc.
2. Titus; brand of Johnson Controls International plc, Global Products.

B. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with blades set at 45 degrees, horizontal face.

C. Frame: 1 inch margin with concealed mounting.

D. Fabrication: Steel with 20 gage minimum frames and 22 gage minimum blades, steel and aluminum with 20 gage minimum frame, or aluminum extrusions, with factory baked enamel finish, color as selected.

E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.

F. Gymnasiums: Furnish front pivoted or welded in place blades, securely fastened to be immobile.

2.4 CEILING GRID CORE EXHAUST AND RETURN REGISTERS/GRILLES

A. Manufacturers:

1. Anemostat Products; a Mestek company.
2. Titus; brand of Johnson Controls International plc, Global Products.

B. Type: Fixed grilles of 1 x 1 x 1 inch louvers.

C. Fabrication: Aluminum with factory baked enamel finish.

D. Frame: 1-1/4 inch margin with concealed mounting.

E. Damper: Integral, gang-operated, opposed-blade type with removable key operator, operable from face.

2.5 WALL EXHAUST AND RETURN REGISTERS/GRILLES

A. Manufacturers:

1. Anemostat

B. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with spring or other device to set blades, horizontal face.

C. Frame: 1 inch margin with concealed mounting.

D. Fabrication: Aluminum extrusions, with factory baked enamel finish, color to be selected.

E. Damper: Integral, gang-operated, opposed-blade type with removable key operator, operable from face.

2.6 GOOSENECKS

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, of minimum 18 gage galvanized steel.

B. Roof Curb: 16 inch high aluminum construction with continuously welded seams and factory installed nailer strip.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify inlet and outlet locations.

B. Verify ceiling and 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. Refer to Section 23 33 00.

C. Paint visible portion of ductwork behind air outlets and inlets matte black. Refer to Section 09 90 00.

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.

END OF SECTION 23 37 00

SECTION 23 40 00 - HVAC AIR CLEANING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Extended surface high efficiency media filters.
2. Filter frames and housings.
3. Filter gages.

B. Related Sections:

1. Section 23 05 13 - Common Motor Requirements for HVAC Equipment: Product requirements for motors for placement by this section.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 850 - Commercial and Industrial Air Filter Equipment.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

C. Underwriters Laboratories Inc.:

1. UL 586 - High-Efficiency. Particulate, Air Filter Units.

1.3 PERFORMANCE REQUIREMENTS

A. Conform to ARI 850 Section 7.4.

B. Dust Spot Efficiency: Plus or minus 5 percent.

1.4 SUBMITTALS

A. Product Data: Submit data on filter media, filter performance data, dimensions, and electrical characteristics.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience.

1.6 EXTRA MATERIALS

A. Furnish two (2) of renewable media filters.

PART 2 - PRODUCTS

2.1 EXTENDED SURFACE HIGH EFFICIENCY MEDIA FILTERS

A. Manufacturers:

1. AirGuard; Clarcor Air Filtration Products, Inc.
2. Flanders Corporation.
3. Koch Filter Corporation.
4. Purolator; Clarcor Air Filtration Products.

B. Media: Pleated, water-resistant glass fiber with aluminum separators; in 16 gage steel holding frame with corrosion resistant coating.

1. Nominal Size: As per unit requirements.

C. Performance Rating, ASHRAE 52.1:

1. MERV-14
2. Initial Resistance at 400 fpm.
3. Recommended Final Resistance: 1.5 inch wg.

2.2 FILTER FRAMES AND HOUSINGS

A. Manufacturers:

1. AirGuard; Clarcor Air Filtration Products, Inc.
2. Flanders Corporation.
3. Koch Filter Corporation.

B. General: Fabricate filter frames and supporting structures of 16 gage galvanized steel or extruded aluminum T-section construction with necessary gaskets between frames and walls.

C. Standard Sizes: For interchange ability of filter media of other manufacturers; for panel filters, size for filter media, minimum 2 inches thick; for extended surface and high efficiency particulate air filters, provide for upstream mounting of panel filters.

D. Side Servicing Housings: Flanged for insertion into ductwork, of reinforced 16 gage galvanized steel; access doors with continuous gaskets and positive locking devices on both sides; extruded aluminum tracks or channels for primary and secondary filters with positive sealing gaskets.

2.3 FILTER GAGES

A. Manufacturers:

1. General Aire.

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 0-2.0 inch wg, 2 percent of full scale accuracy.

C. Accessories: Static pressure tips with integral compression fittings, 1/4 inch aluminum tubing, 2-way or 3-way vent valves.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filters with felt, rubber, or neoprene gaskets to prevent passage of unfiltered air around filters.

B. 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.

C. Do not operate fan system until permanent filters are in place. Replace temporary filters used during construction and testing, with clean set.

D. Install filter gages on filter banks with separate static pressure tips upstream and downstream of filters.

END OF SECTION 23 40 00

SECTION 23 74 16.11 - PACKAGED, SMALL-CAPACITY, ROOFTOP AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged rooftop air conditioning unit.
2. Roof curb.

B. Related Sections:

1. Section 23 09 23 - Direct-Digital Control System for HVAC: Controls remote from unit.
2. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation applying to units in this section.
3. Section 23 33 00 - Air Duct Accessories: Flexible connections.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. ARI 270 - Sound Rating of Outdoor Unitary Equipment.
3. ARI 340/360 - Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.

B. Air Movement and Control Association International, Inc.:

1. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
2. ASHRAE 62 - Ventilation for Acceptable Indoor Air Quality.
3. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.

1.3 DEFINITIONS

A. Energy Efficiency Ratio (EER) - Ratio of net cooling capacity in Btuh to total rate of electric input in watts under designated operating conditions.

B. Seasonal Energy Efficiency Ratio (SEER) - Total cooling output of an air conditioner during its normal annual usage period for cooling (in Btu) divided by total electric energy input during the same period (in Wh).

1.4 SUBMITTALS

A. Product Data: Submit data indicating:

1. Cooling and heating capacities.
2. Dimensions.
3. Weights.
4. Rough-in connections and connection requirements.
5. Duct connections.
6. Electrical requirements with electrical characteristics and connection requirements.
7. Controls.
8. Accessories.

B. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include start-up instructions.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of controls installed remotely from units.

B. Operation and Maintenance Data: Submit manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.6 QUALITY ASSURANCE

A. Cooling Capacity: Rate in accordance with ARI 210/240.

B. Sound Rating: Measure in accordance with ARI 270.

C. Insulation and adhesives: Meet requirements of NFPA 90A.

D. Performance Requirements: Conform to minimum SEER prescribed by ASHRAE 90.1 when tested in accordance with ARI 210/240.

E. Outside Air Damper Leakage: Test in accordance with AMCA 500.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three (3) years' experience.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Accept units on site. Inspect for damage.

B. Protect units from damage by storing off roof until roof mounting curbs are in place.

1.9 COORDINATION

A. Coordinate installation of roof curbs with roof structure, roof deck and roof membrane installation.

1.10 MAINTENANCE SERVICE

A. Furnish service and maintenance of equipment for one year from Date of Substantial Completion. Include maintenance items as shown in manufacturer's operating and maintenance data, including filter replacements, fan belt replacement, and controls checkout and adjustments.

B. Furnish 24-hour emergency service on breakdowns and malfunctions for this maintenance period.

1.11 EXTRA MATERIALS

A. Furnish two (2) of filters for each unit.

PART 2 - PRODUCTS

2.1 GENERAL

A. Supply and install an Air Wise Sales Inc. model NJ-3-RA-D11 air handler (with packaged cooling) for outdoor installation. Unit to have separate hot water heating and humidification source.

2.2 UNIT CONSTRUCTION

A. Cabinet:

1. The support frame will be made of painted heavy gauge formed galvanized steel. Standard height is 6”.
2. The walls and roof of the unit will be double wall and built with outer walls to be a minimum 20 gauge G-90 galvanized steel; inner walls a minimum 22 gauge G-90 galvanized steel; insulation 2-inches thick foam R 13, Thermal break.

3. Floors will be a minimum inner 20 gauge G-90 galvanized steel; outer floor to be built with a minimum 22 gauge G-90 galvanized steel and 22Ga 304SS in cooling coil section, insulation to be minimum 2-inches thick R 13.
4. The roof shall be constructed with a bent 20 gauge G-90 galvanized steel full parameter exterior gutter. The roof panels will be screwed assembled together and sealed with a PVC gasket and a urethane joint for positive waterproofing and air tightness.
5. Controls and piping shall be installed inside a protective enclosure with full-sized hinged access door for easy maintenance.

B. Finish:

1. The external surfaces of the units are manufactured in G90 galvanized steel standard. The finish can be left as such or painted with standard air dried Acrylic Enamel paint. The process is to meet type TT-P-636 D standards for salt, mist and humidity.

C. Doors:

1. Each unit section will have a hinged access door lined UL recognized automotive continuous bulb gaskets and be equipped with lever handles to have access to every component of the equipment. Doors can swing in or out depending on which section they access. They shall be designed to open against the cabinet pressure to prevent any harm while opening the door.
2. The doors shall be double wall constructed of the same materials as the unit casing. The door frame shall be constructed of minimum 20 gauge G-90 galvanized steel. The door opening height shall be adjusted to each door with a minimum 4 inches smaller than the cabinet height.

D. Fans Section:

1. The fan section will be designed according to the Air Movement and Control Association (AMCA) standards. The fan and motor will be installed on a formed steel structure and 1" deflection spring vibration isolated fan and motor assembly. A hinged access door will provide access for maintenance of the fan, motor, bearings, belts and pulleys. The fan will be plenum fan. The motor will be totally enclosed fan-cooled (TEFC) and Premium Efficiency rated for higher efficiency; the fan/motor assembly will be installed on a unitary base.

E. Drain Pans:

1. All drain pans in the equipment shall be 304L stainless steel 2” sloped drain pan with a minimum 1” NPT drain. The drain pans are to be installed on the unit floor and not part of the unit’s welded base.

F. Filters

1. The filters shall be pleated large surface disposable type, 2-inch thick and 35% efficient media MERV 8, Class 2, UL rated. These will be installed in the fresh and return air flow.
2. MERV 14, 12” thick media will be installed at the end of the unit in the supply airflow.

3. Filters will be mounted inside the unit in galvanized steel sliding frames, and accessible through a hinged access door; rubber gaskets will be provided where required to ensure tightness between filters and access door, to avoid air by-pass and maximize filtration.

G. Dampers:

1. The dampers will be opposed blades standard Low leakage, aluminium extruded, airfoil opposed blades.

H. Cooling DX:

1. The unit is to be equipped with a Dx Cooling coil two circuits interlaced with a capacity of 32 tons. It will be factory pre-piped to a side mounted condensing unit that will be composed of a compressor rack that will have one modulating compressor and two one-stage compressors for modulation. The Dx coil is sized to bring the air down from ambient to 52/52°F.

    a. 304 Stainless steel coil casing, racks and blank offs
    b. DX coil with copper tubes/aluminum fins.
    c. Condenser coil(s) with copper tubes/aluminum fins
    d. Direct driven propeller type condenser fans
    e. High efficiency scroll compressors.
    f. Refrigerant piping including ancillaries such as TX valve, sight glass, etc.
    g. 5 Years compressors warranty, material only.

I. Hoods:

1. The air hoods will be “angle” type, mounted on unit end, and equipped with a 1” galvanized steel bird screen as well as rain gutters.
2. Hood air velocity shall not exceed 500 FPM.
3. Hoods shall be constructed of the same materials as the unit’s exterior with a minimum 20ga G-90 galvanized steel construction. It shall also be of the same finish as the equipment.

J. Air Controls:

1. 100% O/A.

K. Electricity and Controls:

1. Mitsubishi VFD; mounted and wired for night airflow setback
2. Non-fused disconnect switch mounted and wired for single power connection
3. Native BACnet Distech DDC controller with MS/TP protocol and remote Smart-vue stat with display/touch screen

L. Start –Up and Factory Adjustment:

1. Each unit shall be tested and pre-adjusted at factory prior to shipment. On site start-up shall be performed by a qualified technician and authorized by the manufacturer.

M. Warranty:

1. Two(2) years parts warranty.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify roof curbs are installed and dimensions are as shown on shop drawings and instructed by manufacturer.

3.2 INSTALLATION

A. Roof Curb:

1. Assemble roof curb.
2. Install roof curb level.
3. Coordinate curb installation and flashing.
4. Install units on roof curb providing watertight enclosure to protect ductwork and utility services.
5. Install gasket material between unit base and roof curb.

B. Install units on vibration isolators.

C. Connect units to supply and return ductwork with flexible connections. Refer to Section 23 33 00.

D. Install condensate piping with trap and route from drain pan to nearest roof drain.

E. Install components furnished loose for field mounting.

F. Install electrical devices furnished loose for field mounting.

G. Install control wiring between unit and field installed accessories.

H. Remove from roof and dispose off-site panels removed from units during installation of dampers.

I. Locate remote panels as indicated on Drawings.

3.3 INSTALLATION - HOT WATER HEATING COIL (mounted in ductwork)

A. Make connections to coils with unions or flanges.

B. Connect water supply to leaving airside of coil (counter flow arrangement).

C. Locate water supply at bottom of supply header and return water connection at top.

D. Install water coils to allow draining and install drain connection at low points.

E. Install valves and piping specialties in accordance with details as indicated on Drawings.

F. Install automatic air vents at high points complete with shutoff valve. Refer to Section 23 21 13.

G. Install hot water piping accessories below roof.

3.4 MANUFACTURER'S FIELD SERVICES

A. Furnish initial start-up and shutdown during first year of operation, including routine servicing and checkout.

3.5 CLEANING

A. Vacuum clean coils and inside of unit cabinet.

B. Install temporary filters during construction period. Replace with permanent filters at Substantial Completion.

3.6 DEMONSTRATION

A. Demonstrate unit operation and maintenance.

END OF SECTION 23 74 16.11

SECTION 23 81 43 - AIR-SOURCE UNITARY HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged energy recovery outside air units.
2. Unitary heat pumps.

B. Related Sections:

1. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation applying to units in this section.
2. Section 23 21 13 - Hydronic Piping: Execution requirements for condenser water and drain piping specified by this section.
3. Section 23 33 00 - Air Duct Accessories: Product requirements for flexible connections for placement by this section.
4. Section 23 40 00 - HVAC Air Cleaning Devices: Product requirements for Air Filters for placement by this section.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. ARI 270 - Sound Rating of Outdoor Unitary Equipment.
3. ARI 340/360 - Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.

B. Air Movement and Control Association International, Inc.:

1. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.

D. Underwriters Laboratories, Inc.:

1. UL 1995 - Heating and Cooling Equipment.

1.3 DEFINITIONS

A. Coefficient of Performance (COP), heat pump, heating - Ratio of rate of heat delivered to rate of energy input, in consistent units, for complete heat pump system, including compressor and, if applicable, auxiliary heat, under designated operating conditions.

B. Energy Efficiency Ratio (EER) - Ratio of net cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions.

C. Heating Seasonal Performance Factor (HSPF) - Total heating output of heat pump during its normal annual usage period for heating (in Btu) divided by total electric energy input during the same period.

D. Seasonal Energy Efficiency Ratio (SEER) - Total cooling output of an air conditioner during its normal annual usage period for cooling (in Btu) divided by total electric energy input during the same period (in Wh).

1.4 SUBMITTALS

A. Shop Drawings: Indicate dimensions, rough-in connections, and duct connections of manufactured products and assemblies. Indicate electrical service with connection requirements.

B. Product Data: Submit drawings indicating capacity, weights, electrical characteristics and connection requirements. Indicate electrical characteristics.

C. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include start-up instructions.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of controls separate from units.

B. Operation and Maintenance Data: Submit manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.6 QUALITY ASSURANCE

A. Air Cooled Equipment:

1. Cooling Performance Requirements: Conform to minimum SEER prescribed by ASHRAE 90.1 when tested in accordance with ARI 210/240.
2. Heating Performance Requirements: Conform to minimum COP prescribed by ASHRAE 90.1 when tested in accordance with ARI 210/240.

B. Sound Rating: Measure in accordance with ARI 270.

C. Outside Air Damper Leakage: Test in accordance with AMCA 500.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience, and with service facilities within 100 miles of Project.

1.8 DELIVERY, STORAGE AND HANDLING

A. Accept units on site in factory packaging. Inspect for damage.

B. Protect units from damage by providing temporary covers until construction is complete in adjacent space.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.10 WARRANTY

A. Furnish five-year manufacturer's warranty for Compressors.

1.11 MAINTENANCE SERVICE

A. Furnish service and maintenance of packaged heat pump roof top units for one (1) year from Date of Substantial Completion. Include maintenance items as shown in manufacturer's operating and maintenance data, including filter replacements, fan belt replacement, and controls checkout and adjustments. Furnish 24-hour emergency service on breakdowns and malfunctions.

1.12 EXTRA MATERIALS

A. Furnish two (2) of filters for each unit.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

A. Furnish and install an indoor horizontal dedicated outside air system (DOAS) designed to provide fresh air into the conditioned space. It shall have the performance, electrical characteristics, and air path configurations as defined in the product schedule for the space.

B. The unit shall be an Alpha Aire air-cooled packaged system manufactured by United CoolAir, York, Pennsylvania or approved equal.

C. The unit shall be installed as a ceiling mounted self-contained system in conjunction with the space air conditioner system for the sole purpose to provide fresh air.

D. All systems shall be shipped with a factory refrigerant charge and be ready to wire once the units have been placed on site.

E. A wiring diagram shall be affixed to each unit. A printed Installation, Operation and Maintenance Manual shall be provided with each unit. All units shall be suitably labeled for safety purposes and for access. A web-based wiring diagram shall be available.

2.2 QUALITY ASSURANCE

A. Unit shall be certified in accordance with UL Standard 1995 safety Standard for Heating and Cooling Equipment

B. Units shall be factory evacuated, charged with refrigerant R-410A, leak tested, and functionally tested prior to shipment.

2.3 SUBMITTALS

A. Literature shall be provided that indicates unit dimensions, applicable clearances, unit operating weights, capacities, blower performance, filter information, factory supplied options, electrical characteristics, and connection requirements.

B. Installation, Operation, and Maintenance manual shall be provided.

C. Wiring Diagrams shall be provided.

2.4 DELIVERY, STORAGE AND HANDLING

A. Unit shall be shipped with all access panels in place and suitably affixed to prevent damage during transportation and thereafter while in storage either offsite or on the jobsite.

B. Unit is to be inspected upon delivery and prior to signing receipt accepting equipment. Any damage during transportation should be reported to the freight handler at the time of delivery.

C. Unit shall be stored in a clean, dry place protected from construction traffic and the natural elements.

D. Installing contractor shall follow industry accepted practices and instructions in the Installation, Operation and Maintenance manual for moving unit where required.

2.5 WARRANTY

A. Manufacturer shall provide a “parts only” limited warranty for a period of 12 months from the date of equipment start-up or 18 months from date of shipment from the factory, whichever is less.

B. Manufacturer shall provide a “compressor parts only” limited warranty for a period of 60 months from the date of equipment start-up or 66 months from date of shipment from the factory, whichever is less.

C. Manufacturer’s limited warranty shall be for parts only. Labor is not included. Labor warranty is to be provided by the Contractor.

2.6 CABINET

A. Cabinet shall be unpainted, non-weatherized and constructed of scratch resistant heavy duty galvanized G90 steel.

B. Cabinet shall be shipped as a self-contained unit on a single skid from the manufacturer. Cabinet shall be assembled using zinc plated fasteners.

C. Horizontal Unit shall be provided with integral support rails and integral hanging brackets which eliminate the need for external, field-supplied brackets. Brackets shall accommodate the unit being ceiling mounted using hanging rods or slab mounted.

D. Cabinet access panels shall fit into recessed pockets within the cabinet structure and held in place with screws or tool-operated quick-turn fasteners. Recessed areas will be lined with flexible gasket to minimize air leakage. Some access panels shall have inserts to easily facilitate panel removal. Service panels for filter maintenance are hinged for ease of service.

E. Panels shall allow side access to key internal components to facilitate installation, maintenance and servicing of the unit. The front end panel (horizontal) will be hinged to allow for ease of access.

F. Duct flanges shall be factory-installed prior to shipment for side supply and exhaust/return air configurations. This side panel is field reversible and duct flanges and panel gasket must be moved for opposite side supply and exhaust/return air configuration.

G. The back of the cabinet shall have an inlet and outlet for outside air intake and exhaust air discharge.

H. Cabinet and removable panels shall be lined with 2”, R-8 fiberglass, solid double wall thermal/acoustic insulation and ¼” rubberized PVC. Insulation shall not promote or support the growth of fungi or bacteria. Insulation shall include an acrylic polymer coating to help guard against the incursion of dust and dirt into the substrate.

I. Double Wall with Solid Liner - Cabinet and removable panels shall be double-wall construction with interior panels consisting of solid galvanized metal.

2.7 ENTHALPY WHEEL

A. The system shall utilize a total enthalpy wheel to capture waste heat energy from the building exhaust air stream for conditioning of the entering outdoor air stream. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt. The wheel shall not allow more than 5% crossover between the supply and exhaust air stream. The total energy recovery wheel shall be coated with silica gel desiccant permanently bonded without the use of binders or adhesives. The substrate shall be lightweight polymer. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity. The wheel shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix. The wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

2.8 PLATE HEAT EXCHANGER

A. The plate heat exchanger will have a maximum temperature of 190°F. The plate heat exchanger shall have a maximum leakage of 0.1% at nominal air flow with non-silicone sealant at 400 Pa WC differential pressure. The plate material shall be aluminum. The frame material corner profiles shall be aluminum or aluzinc.

2.9 REFRIGERANT CIRCUIT

A. Refrigerant circuit shall be provided with high and low-side Schrader access valves, sight glass with integral moisture indicator, filter-drier, maximum operating pressure (MOP) expansion valve with external equalizer line, expansion valve with internal equalizer line, manual reset high and auto-reset low pressure safety switches.

B. Refrigerant circuit will be factory leak tested, evacuated, and charged with R-410A refrigerant and run tested prior to shipment.

C. Units shall contain a 1-row auxiliary/reheat coil and a receiver tank for refrigerant management. The auxiliary/reheat coil shall be constructed of copper tubing mechanically expanded into aluminum fins. The fin spacing shall be 13 fins per inch. The auxiliary/reheat coil shall be mounted a minimum of 8” after the evaporator coil for ease of cleaning and to prevent re-hydration of the condensate from the evaporator coil.

D. The Compressor section is to be provided with resealable refrigerant fittings in order to allow for compressor replacement requiring no recovery of refrigerant, brazing, and evacuation or charging of the unit using a factory compressor retrofit kit.

E. Heat Pump Cycle unit will be equipped with a solenoid valve operating a 4-way valve. In addition, the refrigeration circuit will shall contain a suction accumulator.

2.10 COMPRESSOR

A. Refrigerant circuit shall utilize a single (.75 ton) rotary compressor. Compressor shall be mounted on vibration isolators to ensure quiet operation. Compressor shall be protected internally from overheating.

B. Compressor shall be mounted outside the air stream in an insulated compartment.

C. Compressor circuit shall be protected with a high and low pressure safety switch.

D. Compressor shall have acoustic cover for sound attenuation.

2.11 EVAPORATOR COIL SECTION

A. Evaporator coil shall be made with heavy wall seamless copper tubes mechanically expanded into tempered aluminum fins with drawn self-spacing collars. Coil end sheets shall be hot-dipped galvanized. Coils shall be 6 rows deep and 13 FPI for uniform performance and optimum part load and humidity operation. All coils shall be factory leak checked under pressure.

B. A maximum operating pressure (MOP), adjustable thermostatic expansion valves, externally equalized, shall feed the evaporator coil.

C. Evaporator coil section shall be equipped with a double sloped 304 stainless steel drain pan with 3/4” NPT female connection condensate drain connection located on the side of the cabinet. Drain pan shall extend to the entire length and width of the evaporator coil.

D. Evaporator section air path shall be as shown on project drawings.

2.12 CONDENSER COIL SECTION

A. Condenser coil shall be made with heavy wall seamless copper tubes mechanically expanded into tempered aluminum fins with drawn self-spacing collars. Coil end sheets shall be hot-dipped galvanized. Coils shall be 4 rows deep and 18 FPI for uniform performance and optimum part load and humidity operation. All coils shall be factory leak checked under pressure.

B. A maximum operating pressure (MOP), adjustable thermostatic expansion valve, internally equalized shall feed the condenser coil.

C. Condenser coil section shall be equipped with a double sloped 304 stainless steel drain pan with 3/4" NPT female connection condensate drain connection located on the side of the cabinet. Drain pan shall extend to the entire length and width of the condenser coil.

2.13 BLOWER / MOTOR ASSEMBLIES

A. Unit shall incorporate ECM blowers.

B. The unit supply and exhaust fans shall consist of centrifugal backward curve fans with electronically commutated motors (ECM). The motor RPM shall be directly set by the package unit control system. The balancing contractor shall have direct access to set the motor RPM through the unit control system.

C. Section shall include a factory-installed, fan motor fault proving switch. Upon loss of fan motor operation, this control shall enunciate.

2.14 ELECTRICAL SYSTEM

A. Unit shall have a single isolated electrical control panel located out of the air stream. Access to the control panel shall be from the rear on a horizontal unit and from the front on a vertical unit. A single point power connection shall be provided through the right or left side of the cabinet. Power shall be connected to factory installed terminal blocks. Ground lug shall be affixed in the control panel.

B. A low-voltage transformer, with protection, shall be provided to supply 24 VAC to the control circuit.

C. Terminal strips and blocks shall be factory installed internal to the control box and be clearly labeled for control wiring connections. External control wires shall enter the cabinet through the right or left side of the cabinet.

D. Terminal blocks shall be factory provided for a Remote On / Off switch capability. Controls shall be suitably wired and enabled to accept a signal from a field supplied Remote On / Off switch.

E. Terminal blocks shall be factory provided for a Fire / Smoke Detector sensor interface. Controls shall be suitably wired and enabled to accept a signal from a Fire / Smoke Detector.

F. Terminal blocks shall be factory provided for an External Condensate Pump / Float Switch interface. Controls shall be suitably wired and enabled to accept a signal from an External Condensate Pump / Float Switch.

G. The unit shall contain a self-contained microprocessor with BACNet MS/TP.

2.15 FILTRATION

A. The evaporator and condenser filters shall be factory mounted in the unit cabinet and shall be accessible from right or left side.

B. Filters shall be nominal 2”+4” Outside Air depth pleated, throwaway type panel filters consisting of cotton and synthetic or synthetic only media with galvanized expanded metal backing and moisture resistant enclosing frame. The filter shall be classified for flammability by Underwriters Laboratories, Inc. as Class 2.

C. The filter media shall have an efficiency of MERV 8 and MERV 13 Outside Air] based on ASHRAE test standard 52.2.

D. The filter face area shall contain not less than 10 pleats per lineal foot. Media support shall be heavy gauge expanded, electro-galvanized metal with grid members being no less than 0.025”wide, providing an open area of not less than 96%. The grid shall be 100% bonded to the media on the air exiting side to eliminate media vibration and pull-away. The grid shall be formed to provide a uniform V-shaped pleat with the open area on the air exiting matched to the open area on the air entering side for maximum utilization of the media and low airflow resistance. The enclosing frame shall be constructed of a rigid, high wet strength board.

2.16 SYSTEM OPTIONS

A. EZ Trap Kit – A Trap / Float Switch Combo Kit shall be field assembled and wired to the unit microprocessor. Kit includes plastic cleanout tees, cleanout brush, clear trap and float activated switch. Provides high water alarm when switch is activated. Provide two kits.

B. Non-Fused Disconnect – UL approved indoor non-fused disconnect shall be shipped loose for field installation separate from the unit.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify piping rough-in is at correct location.

B. Verify electrical rough-in is at correct location.

3.2 INSTALLATION

A. Locate remote panels as indicated on Drawings.

B. Install indoor units on vibration isolators.

C. Connect indoor units to supply and return ductwork with flexible connections.

D. Install condensate piping from drain pan to location shown on Plans

E. Install accessories furnished loose for field mounting.

F. Install electrical devices furnished loose for field mounting.

G. Install control wiring between unit control panel and field mounted control devices.

3.3 MANUFACTURER'S FIELD SERVICES

A. Furnish initial start-up and shutdown during first year of operation, including routine servicing and checkout.

3.4 CLEANING

A. After construction is completed, including painting, clean exposed surfaces of units.

B. Vacuum clean coils and inside of cabinets.

C. Touch up marred or scratched surfaces of factory finished cabinets, using finish materials furnished by manufacturer.

D. Install new filters in units after Substantial Completion.

3.5 DEMONSTRATION

A. Demonstrate unit operation and maintenance.

B. Furnish services of manufacturer's technical representative for one (1) hour day to instruct Owner's personnel in operation and maintenance of units. Schedule training with Owner, provide at least 7 days' notice to Architect/Engineer of training date.

3.6 PROTECTION OF FINISHED WORK

A. Protect finished surfaces of cabinets with protective covers during remainder of construction.

END OF SECTION 23 81 43

SECTION 23 81 46 - WATER-SOURCE UNITARY HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Horizontally mounted water source heat pumps.

B. Related Sections:

1. Section 23 09 23 - Direct-Digital Control System for HVAC: Controls remote from unit.
2. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation applying to units in this section.
3. Section 23 21 13 - Hydronic Piping: Water and drain piping connections.
4. Section 23 33 00 - Air Duct Accessories: Flexible connections.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 260 - Sound Rating of Ducted Air Moving and Conditioning Equipment.
2. ARI 320 - Water Source Heat Pump Equipment.

B. Air Movement and Control Association International, Inc.:

1. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
2. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.

D. International Organization for Standardization:

1. ISO 13256-1 - Water-Source Heat Pumps - Testing and Rating for Performance - Part 1: Water-to-Air and Brine-to-Air Heat Pumps.

E. National Electrical Manufacturers Association:

1. NEMA WD 6 - Wiring Devices-Dimensional Requirements.

F. National Fire Protection Association:

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

G. Underwriters Laboratories, Inc.:

1. UL 1995 - Heating and Cooling Equipment.

1.3 DEFINITIONS

A. Coefficient of Performance (COP), heat pump, heating - Ratio of rate of heat delivered to rate of energy input, in consistent units, for complete heat pump system, including compressor and, if applicable, auxiliary heat, under designated operating conditions.

B. Energy Efficiency Ratio (EER) - Ratio of net cooling capacity in Btuh to total rate of electric input in watts under designated operating conditions.

1.4 SUBMITTALS

A. Product Data: Submit data indicating:

1. Cooling and heating capacities.
2. Dimensions.
3. Rough-in connections and connection requirements.
4. Duct connections.
5. Controls.
6. Accessories.
7. Installation, operation and service clearances. Indicate lift points and recommendations and center of gravity.
8. Indicate unit shipping, installation and operating weights.
9. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or maximum circuit ampacity.

B. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include start-up instructions.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data. Include parts list and wiring diagrams.

1.6 QUALITY ASSURANCE

A. Cooling Performance Requirements: Conform to minimum EER prescribed by ASHRAE 90.1 when tested in accordance with ISO 13256-1.

B. Heating Performance Requirements: Conform to minimum COP prescribed by ASHRAE 90.1 when tested in accordance with ISO 13256-1.

C. Performance ratings in accordance with ARI 320.

D. Sound Rating: Measure in accordance with ARI 260.

E. Insulation and adhesives: Meet requirements of NFPA 90A.

F. Outside Air Damper Leakage: Test in accordance with AMCA 500.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three (3) years' experience.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Accept units on site. Inspect for damage.

B. Comply with manufacturers installation instructions for rigging, unloading and transporting units.

C. Protect units from damage by storing in manufacturer's packaging until ready for installation.

1.9 COORDINATION

A. Coordinate unit installation with roof structure, piping systems, and ceiling for unit access.

1.10 WARRANTY

A. Furnish five-year manufacturer's warranty for compressors.

1.11 MAINTENANCE SERVICE

A. Furnish service and maintenance of equipment for one (1) year from Date of Substantial Completion. Provide maintenance items shown in manufacturer's operating and maintenance data, including filter replacements, fan belt replacement, and controls checkout and adjustments.

1.12 EXTRA MATERIALS

A. Furnish one set of filters for each unit.

PART 2 - PRODUCTS

2.1 HORIZONTAL WATER SOURCE HEAT PUMPS

A. Manufacturers:

1. United Cool Air.
2. ClimateMaster, Inc.
3. Comfort-Aire; a division of Heat Controller, Inc.

B. Operating Temperatures: See Schedule.

C. Configuration: Horizontal.

D. Cabinet: Factory assembled and wired consisting of galvanized steel cabinet with 1/2 inch thick glass fiber insulation on interior, discharge duct collar and return collar with filter rack.

1. Hanging Brackets: Located at each corner, and capable of receiving vibration isolation.

E. Motor and Fan Assembly:

1. Drive: Direct type.
2. Motor: Three speed high efficiency permanent split capacitor with permanently lubricated and sealed bearings and internal thermal overload protection.

a. Furnish high external static pressure motors as indicated on Drawings.

3. Fan Discharge: Field convertible for back, left, or right discharge.
4. Motor and fan wheel: Removable.

F. Air-to-Refrigerant Coil:

1. Constructed of copper tubes mechanically expanded into aluminum fins; leak tested at 450 psi operating pressure; tubes completely evacuated of air prior to shipment.
2. Refrigerant coil distributor assembly: orifice style with round copper distributor tubes sized consistent with capacity of coil; suction headers fabricated from rounded copper pipe.

G. Drain Pan: Constructed of corrosion resistant material and insulated to prevent sweating. Bottom sloped in two directions.

H. Water-to-Refrigerant Heat Exchanger:

1. Co-axial type; constructed of copper; fluted to enhance heat transfer and minimize fouling and scaling.
2. Working pressure: 450 psi on refrigerant side and 400 psi on water side.

I. Refrigeration System:

1. Compressor: Rotary, reciprocating, or scroll type. Furnish with the following:

    a. External vibration isolation.
    b. Thermal overload protection.

2. Reversing Valve: Pilot operating sliding piston type with replaceable encapsulated magnetic coil. Valve energized in cooling mode.
3. Refrigerant Tubing: Constructed of copper; free from contaminants and conditions such as drilling fragments, dirt, and oil.
4. Refrigerant Metering: Furnish with thermal expansion valve (TXV) to allow operation of unit with entering fluid temperatures from 25 degrees F to 120 degrees F. Capillary tubes are not acceptable.

J. Filters: 2 inch thick throwaway type MERV 14.

K. Control Panel: Factory tested and installed containing devices to allow heating and cooling operation to occur from remote device. Furnish the following:

1. 24 volt AC contactor for compressor control.
2. Terminal strip.
3. Safety lockout relay to prevent cycling of compressor during adverse conditions of operation. Capable of being reset at remote thermostat or zone sensor or by cycling power to unit.
4. High pressure switch.
5. Low pressure switch.

L. Controls: Factory-wired, tested, and commissioned. Each water source heat pump controlled by communicating microprocessor-based controller with resident control logic. Furnish controller with the following features:

1. 24 volt AC control transformer with integral circuit breaker.
2. Random start.
3. Anti-short cycle protection.
4. Condensate overflow safeties.
5. Brownout protection.
6. Furnish status for the following:

    a. Heating or cooling.
    b. Occupied or unoccupied cycle.
    c. Fan.
    d. Filter.

7. Low water temperature sensor.
8. Ability to control to four set points: occupied, occupied standby, occupied bypass (timed-override), and unoccupied.
9. Capability of receiving the following commands from Building Management System: mode - occupied and unoccupied, demand limiting sequence, emergency shutdown, and time-of-day scheduling.

10. Field service interface for diagnostic and troubleshooting purposes.
11. Capability of communicating specific diagnostics, not general alarm, to Building Management System:

    a. Space set point.
    b. Discharge air temperature.
    c. Leaving water temperature.
    d. Unit alarms with manual reset include: high pressure, low pressure, and condensate overflow.
    e. Unit alarms with automatic reset include: fan and filter status and low water temperature.

12. Building Management System: Interface control module to Building Management System furnished and factory mounted by manufacturer. Through this interface module, perform Building Management functions. Furnish controls and sensors factory mounted. Limit field connection to Building Management System to single communication link.
13. Zone thermostat with one set point and override button.

M. Automatic Flow Devices: Automatic self-balancing device to limit flow rate within 10 percent of scheduled flow rate, over 40 to 1 differential pressure operating range of 2 psi to 80 psi differential. Operating temperature range: from freezing to 225 degrees F. Furnish with dual pressure-temperature test ports.

N. Motorized Water Valve: Opens when compressor is energized, and closes as compressor shuts down. Furnish valve with fast opening and slow closing characteristics.

O. Capacity: See Schedule.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify piping rough-in is at correct location.

B. Verify electrical rough-in is at correct location.

3.2 INSTALLATION

A. Locate units as indicated on Drawings, level and shim units, and anchor to structure.

B. Install units on vibration isolators.

C. Connect units to supply and return ductwork with flexible connections.

D. Make connections to coils with unions or flanges.

E. Install the following piping accessories on condenser water piping connections. Refer to Section 23 21 13.

1. On Inlet:

a. Thermometer well for temperature limit controller.
b. Thermometer well and thermometer.
c. Strainer.
d. Flow switch.
e. Flexible pipe connection.
f. Pressure gage.
g. Shut-off valve.

2. On Outlet:

a. Thermometer well and thermometer.
b. Flexible pipe connection.
c. Pressure gage.
d. Balancing valve.

F. Install automatic air vents at high points complete with shutoff valve.

G. Install condensate piping with trap and route from drain pan to location shown on Plans.

H. Install components furnished loose for field mounting.

I. Install electrical devices furnished loose for field mounting.

J. Install control wiring between unit and field installed accessories.

3.3 MANUFACTURER'S FIELD SERVICES

A. Furnish initial start-up and shutdown during first year of operation, including routine servicing and checkout.

3.4 CLEANING

A. Vacuum clean coils and inside of unit cabinet.

B. Touch up marred or scratched surfaces of factory finished cabinets, using finish materials furnished by manufacturer.

C. Install temporary filters during construction period. Replace with permanent filters at Substantial Completion.

3.5 DEMONSTRATION

A. Demonstrate unit operation and maintenance.

END OF SECTION 23 81 46

SECTION 23 82 00 - CONVECTION HEATING AND COOLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air coils.

B. Related Sections:

1. Section 23 07 00 - HVAC Insulation: Execution requirements for insulation specified by this section.
2. Section 23 21 13 - Hydronic Piping: Execution requirements for connection of chilled water, hot water, and drain piping to units specified by this section.
3. Section 23 21 16 - Hydronic Piping Specialties: Product requirements for hydronic piping specialties for placement by this section.
4. Section 23 31 00 - HVAC Ducts and Casings: Execution requirements for ducts specified by this section.

1.2 REFERENCES

A. Sheet Metal and Air Conditioning Contractors:

1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

1.3 SUBMITTALS

A. Product Data: Submit coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions. Submit mechanical service locations, capacities and accessories or optional items.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Accept units on site in factory packing. Inspect for damage. Store under roof.

B. Protect coil fins from crushing and bending by leaving in shipping cases until installation, and by storing indoors. Protect coils from entry of dirt and debris with pipe caps or plugs.

1.6 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.1 AIR COILS

A. Manufacturers:

1. Greenheck
2. INDEECO.

B. Fabrication:

1. Tubes: 1/2 inch OD seamless copper arranged in parallel or staggered pattern, expanded into fins, brazed joints.
2. Fins: Aluminum continuous plate type with full fin collars or individual helical spiral finned tube type wound under tension.
3. Casing: Die formed channel frame of 16 gage galvanized steel with 3/8 inch mounting holes on 6 inch centers. Furnish intermediate center tube supports for plate fin coils longer than 36 inches. Furnish intermediate tube supports for spiral fin coils at manufacturer's recommended intervals to eliminate sagging during operation.

C. Water Heating Coils:

1. Headers: Cast iron with tubes expanded into header, seamless copper tube with silver brazed joints, or prime coated steel pipe with brazed joints.
2. Leak Testing: Air test under water to 200 psig for working pressure of 200 psig and 200 degrees F.
3. Configuration: Self draining circuitry, with threaded plugs in headers for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes. Furnish threaded plugs in return bends or in headers opposite top and bottom of each tube.
4. Fin Spacing: See Schedule.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify ductwork is ready for installation.

B. Verify concealed blocking and supports are in place and connections are correctly located.

3.2 INSTALLATION

A. Install air coils in ducts and casings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible..

B. Support air coil sections independent of piping on steel channel or double angle frames and secure to casings. Furnish frames for maximum three coil sections. Arrange supports to avoid piercing drain pans. Install with airtight seal between coil and duct or casing.

C. Protect coils to prevent damage to fins and flanges. Comb out bent fins.

D. Install coils level.

E. Make connections to coils with unions and flanges.

F. On water coils, install shut-off valve on supply piping and lockshield balancing valve on return piping. Locate water supply at bottom of supply header and return water connection at top. Install float operated automatic air vents at high points complete with stop valve. Install water coils to be drainable and install drain connection at low points.

G. On water heating coils, connect water supply piping to leaving airside of coil (counter flow arrangement).

H. Install insulation air coil casings. Refer to Section 23 07 00.

I. Units with Cooling Coils: Install drain piping to condensate drain.

3.3 CLEANING

A. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

END OF SECTION 23 82 00

SECTION 23 84 00 - HUMIDITY CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electrically heated, immersion type humidifiers.

B. Related Sections:

1. Section 23 05 13 - Common Motor Requirements for HVAC Equipment: Product requirements for pump motors for placement by this section.
2. Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment: Product requirements for supports for steam grid humidifiers for placement by this section.
3. Section 23 07 00 - HVAC Insulation: Execution requirements for insulating humidifier casings specified by this section.
4. Section 23 09 23 - Direct-Digital Control System for HVAC: Product requirements for control components used by humidity control equipment.
5. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation for humidity control equipment.
6. Section 23 21 13 - Hydronic Piping: Execution requirements for connection of chilled water and hot water to units specified by this section.
7. Section 23 31 00 - HVAC Ducts and Casings: Execution requirements for ducts specified by this section.

1.2 REFERENCES

A. Air-Conditioning and Refrigeration Institute:

1. ARI 630 - Selection, Installation, Servicing of Humidifiers.

B. National Electrical Manufacturers Association:

1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

C. Sheet Metal and Air Conditioning Contractors:

1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

1.3 SUBMITTALS

A. Product Data: Submit catalog sheets indicating general assembly, dimensions, weights, materials, and certified performance ratings duct and service connections, electric nameplate data and wiring diagrams.

B. Manufacturer's Installation Instructions: Submit assembly and setting operations.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit manufacturer's descriptive literature, operating instructions, maintenance and repair data, including instructions for lubrication, filter replacement, cleaning and spare parts lists.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience, and with service facilities within 100 miles of Project.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Accept units on site in factory packing. Inspect for damage.

1.7 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.8 WARRANTY

A. Furnish five-year manufacturer's warranty for units.

1.9 MAINTENANCE SERVICE

A. Section 01 70 00 - Execution and Closeout Requirements: Requirements for maintenance service.

B. Furnish service and maintenance of humidifier for one (1) year from Date of Substantial Completion.

C. Examine unit components bi-monthly. Clean, adjust, and lubricate equipment.

D. Include systematic examination, adjustment, and lubrication of unit, and controls checkout and adjustments. Repair or replace parts in accordance with manufacturer's operating and maintenance data. Use parts produced by manufacturer of original equipment.

E. Perform work without removing units from service during building normal occupied hours.

F. Maintain locally, near Place of the Work, adequate stock of parts for replacement or emergency purposes. Have personnel available to ensure fulfillment of this maintenance service, without unreasonable loss of time.

G. Perform maintenance work using competent and qualified personnel under supervision of manufacturer or original installer.

PART 2 - PRODUCTS

2.1 ELECTRICALLY HEATED, IMMERSION TYPE HUMIDIFIER

A. Manufacturers:

1. Pure Humidifier Company.

B. Product Description: Self-contained humidifier with reservoir, injection tube, and controls.

C. Medium: Standard Water.

D. Evaporating Reservoir: Constructed of type 304 stainless steel with welded joints. Gasket sealed cover capable of operating pressures of 19 inches water column.

E. Removable cover and front access panel for easy cleaning.

F. Cabinet: Reservoir contained within cabinet constructed of 18 gage steel with baked enamel finish. Cabinet floor serves as drain pan with connections for drain piping.

G. Adjustable Surface Water Flusher: To drain away portion of water upon each refill cycle. Flusher height adjustable for minimal water waste and efficient flushing.

H. Water Fill Valve: Brass body, solenoid operated block style water fill valve with internal strainer factory mounted. Bottom fill system to prevent collapse of steam head during fill cycle. Located to allow minimum water gap of 1-1/2 inches.

I. Immersion heaters: Incoloy clad type. Threaded into front of unit.

J. Over Temperature Protection: Manual reset over temperature switch factory installed on humidifier reservoir.

K. Injection Tubes: Constructed of Type 304 round stainless steel steam jacketed injection tubes with emission openings to uniform distribution of steam over entire width of duct. Furnish duct plate for sealing of duct opening.

L. Humidifier Controls: NEMA 250 Type 12 control cabinet factory mounted. Furnish with the following features:

1. Factory wired control valve interlock.
2. Water level control module.
3. Fused control circuit transformer.
4. Numbered terminal block.
5. Main power fuse.
6. Factory mounted, solid state control module for the following functions:

    a. Automatic refilling.
    b. Low water cutoff.
    c. High water cutoff.
    d. Surface water flushing.
    e. Safety switch interlock functions.
    f. Flush mode with automatic drain system.

7. Furnish the following visual indications:

    a. Safety switch interruption.
    b. Power.
    c. Fill.
    d. Heat ready.
    e. Drain.

8. Water level controlled through sensor mounted on reservoir. Control system continues to maintain humidity during fill cycle.

M. Automatic Temperature Controls: Refer to Section 230923 230953. Refer to Section 23 09 93 for humidifier sequence of operation..

N. Control Components: Furnish humidifier with the following:

1. Electric modulating space humidistat.
2. Electric high limit duct humidistat.
3. Air proving switch.

O. Accessories: Furnish humidifier with the following:

1. Automatic timed drain system with motor operated drain valve with brass body, factory installed.
2. Insulation: 1 inch thick glass fiber insulation with aluminum foil facing covering entire unit except front face.
3. SCR Modulating Control: 0 to 100 percent modulation of humidifier output. Factory mounted and wired in control cabinet.
4. Timed cycle modulation: Factory mounted and wired in control panel.
5. Steam hose kit consisting of 2 inch long hoses, injection tube, support rod, hose clamps, and duct plate.
6. Wall brackets for support of humidifier heat exchanger.
7. Automatic seasonal end-of-use humidifier drain.
8. Auto-selector: Furnish factory mounted and wired dual input, single output auto-selector for single modulating output signal to humidifier control cabinet. Auto-selector allows use of modulating space humidistat and modulating duct high limit humidistat to control

critical variable air volume air handling systems. System automatically determines which of two modulating signals is dominant and slowly reduces humidifier output capacity preventing oversaturating of air stream.

9. Condensate cooling system to provide cold water mixing of drain water.

P. Capacity: See Schedule.

Q. Electrical Characteristics and Components: See Schedule.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify ductwork is ready for installation.

B. Verify piping rough-ins are correct size and at correct location.

C. Verify power wiring is correct voltage and at correct location.

3.2 PREPARATION

A. Contact manufacturer to review installation procedures for field installed accessories.

3.3 INSTALLATION - ELECTRIC HUMIDIFIERS

A. Install in accordance with ARI 630.

B. Install loose equipment furnished by manufacturer.

C. Install galvanized steel rods to support distribution manifolds of humidifier and mount in air system plenums.

D. Install wall bracket to support humidifier.

E. Make connections to equipment with unions or flanges.

F. Connect humidifiers to domestic water and to drain piping. Install shutoff valve and strainer on domestic water piping. Install drain piping with trap of depth recommended by manufacturer.

G. Provide control wiring for field installed accessories.

3.4 MANUFACTURER'S FIELD SERVICES

A. Furnish initial start-up and shutdown during first year of operation, including routine servicing and checkout.

3.5 DEMONSTRATION

A. Demonstrate operation and maintenance procedures.

B. Furnish services of manufacturer's technical representative for 4 hours to instruct Owner's personnel in operation and maintenance of units. Schedule training with Owner, provide at least 7 days' notice to Owner of training date.

END OF SECTION 23 84 00