SECTION 15213

MEDICAL GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

A. This Section includes medical gas piping and related specialties for the following medical gas systems:

1. Medical gas pressure systems:

   a. Oxygen piping, designated "O2 - Oxygen."
   b. Medical compressed-air piping, designated "MA - Medical Air."
   c. Nitrous oxide piping, designated "N2O - Nitrous Oxide."
   d. Nitrogen piping, designated "N - Nitrogen."
   e. Carbon dioxide piping, designated "CO2 - Carbon Dioxide."
   f. **<Insert medical gas piping>**, designated "**<Insert designation>**."

2. Medical gas suction systems:

   a. Medical-surgical vacuum piping, designated "MV - Medical Vacuum."
   b. Waste anesthetic gas disposal piping, designated "WAGD."
   c. **<Insert medical gas piping>**, designated "**<Insert designation>**."

B. Owner-Furnished Material: For installation under this Section.

1. **<Insert product.>**

C. Related Sections include the following:

1. Division ** Section "**"

2. Division 7, Section 07270 "Through-Penetration Firestop Systems" for materials and methods for sealing pipe penetrations through fire and smoke barriers.

3. Division 7, Section 07900 "Joint Sealants" for materials and methods for sealing pipe penetrations through exterior walls.
4. Division 15 Section "Meters and Gages" for thermometers and pressure gages.
5. Division 15 Section "Medical Air and Vacuum Equipment" for compressed-air and vacuum equipment and related accessories.

1.3 DEFINITIONS

A. ACR: Air conditioning and refrigeration.

B. CR: Chlorosulfonated polyethylene synthetic rubber.

C. D.I.S.S.: Diameter-index safety system.

D. NPS: Nominal pipe size.

E. PTFE: Polytetrafluoroethylene plastic.

F. TFE: Tetrafluoroethylene plastic.

G. WAGD: Waste anesthetic gas disposal.

1.4 PERFORMANCE REQUIREMENTS

A. General: Provide medical gas and vacuum piping systems that comply with the following NFPA 99 level categories:

1. Level 1: For entire facility with systems where failure of medical gas supply would be immediate and direct life-safety threat to patients. Air and vacuum equipment arrangement must be duplex or redundant.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Medical gas tubes and fittings.
2. Medical gas valves and valve boxes.
3. Medical gas manifolds.
4. Medical gas service connections and pressure control panels.
5. Medical gas service units. Include integral service connections.
6. Alarm system components.
7. Medical gas cylinder storage racks.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Coordination Drawings: For medical gas systems. Include relationship to other services that serve same work area.

D. Brazing Certificates: As required by ASME Boiler and Pressure Vessel Code, Section IX, or AWS B2.2.

E. Piping Material Certification: Signed by Installer certifying that medical gas piping materials comply with NFPA 99 requirements.

F. Certificates of Shop Inspection and Data Report for Bulk Medical Gas Storage Tanks: As required by ASME Boiler and Pressure Vessel Code.

G. Qualification Data: For testing agency.

H. Field quality-control Test and Certification Reports.

I. Operation and Maintenance Data: For medical gas piping and specialties to include in emergency, operation, and maintenance manuals. Include data for the following:

1. Medical gas manifolds.
2. Medical gas service connections and pressure control panels.
3. Medical gas service units.
4. Alarm system.
5. Bulk medical gas storage tanks.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the Medical Gas Professional Healthcare Organization or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

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

D. ASME Compliance: Fabricate and label bulk medical gas storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels."

E. Comply with NFPA 70, "National Electrical Code."

F. Comply with NFPA 99-2002 edition, "Health Care Facilities," for materials, installation, testing and certification.

G. Comply with UL 498, "Attachment Plugs and Receptacles," for electrical service connections.

H. Contamination of existing piping systems caused be faulty workmanship or procedures shall be corrected to the Owner's satisfaction at he Contractor's expense and at no additional cost to the owner.

1.7 COORDINATION

A. Coordinate size and location of concrete bases with concrete work.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Quick-Connect Service Connections: Furnish complete noninterchangeable medical gas pressure outlets and suction inlets.

   a. Oxygen Service Connections: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   b. Medical Air Service Connections: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   c. Nitrous Oxide Service Connections: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   d. Carbon Dioxide Service Connections: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   e. Medical Vacuum Service Connections: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   f. Medical Vacuum Slide Brackets: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   g. WAGD Service Connections: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   h. **<Insert medical gas>** Service Connections: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.

2. D.I.S.S. Connections: Furnish complete noninterchangeable medical gas pressure outlets and suction inlets complying with CGA V-5.

   a. Oxygen D.I.S.S. No. 1240: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   b. Medical Air D.I.S.S. No. 1160: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   c. Nitrous Oxide D.I.S.S. No. 1040: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   d. Carbon Dioxide D.I.S.S. No. 1080: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   e. Medical Vacuum D.I.S.S. No. 1220: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.
   f. Medical Vacuum Slide Brackets: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.

g. WAGD D.I.S.S. No. 2220: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.

h. **<Insert medical gas and D.I.S.S. number>**: Equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.

3. Nitrogen Control Panels: Complete panel with nitrogen CGA V-5, D.I.S.S. No. 1120, equal to **<Insert number>** percent of amount installed, but no fewer than **<Insert number>** units.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Allied Healthcare Products, Inc.; Chemetron Div.
2. Amico Corporation.
3. BeaconMedaes.
4. Squire-Cogswell/Aeros Instruments.
5. **<Insert manufacturer's name.>**

2.2 PIPES, TUBES, AND FITTINGS

A. General: Sizes indicated on the drawings are nominal pipe/tube size, (NPS).

Nominal Pipe/Tube Size, (NPS)	Actual O.D. / ACR Designation (inches)
1/2	5/8
3/4	7/8
1	1-1/8
1-1/4	1-3/8
1-1/2	1-5/8
2	2-1/8
2-1/2	2-5/8
3	3-1/8

B. Hard Copper Tube: ASTM B 819, Type K or L, seamless, drawn-temper, medical gas tube that has been factory cleaned, purged, and sealed for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and blue for Type L tube.

1. Fittings: Factory cleaned, purged, and bagged for oxygen service according to ASTM B 819 or field cleaned, purged, and bagged as specified in "Preparation" Article in Part 3.

    a. Copper Pressure Fittings: ASME B16.22, wrought-copper solder-joint pressure type or MSS SP-73, wrought copper with dimensions for brazed joints.
    b. Cast-Copper-Alloy Flanges: ASME B16.24, Class 300.
    c. Copper Unions: ASME B16.22 or MSS SP-123.

C. Memory-Metal Couplings: Nickel-titanium, shape-memory-alloy, cryogenic compression fitting for joining copper tube without heat.

1. Cleaning: Factory cleaned, purged, and bagged for oxygen service according to ASTM B 819 or field cleaned, purged, and sealed or bagged as specified in "Preparation" Article in Part 3.

D. Flexible Pipe Connectors: Corrugated-bronze inner tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Cleaning: Factory cleaned, purged, and sealed or bagged for oxygen service according to ASTM B 819 or field cleaned, purged, and sealed or bagged as specified in "Preparation" Article in Part 3.
2. Working-Pressure Rating: **[200 psig] [250 psig]** minimum.
3. End Connections NPS 2 (2-1/8" O.D.) and Smaller: Threaded copper pipe or plain-end copper tube.
4. End Connections NPS 2-1/2 (2-5/8" O.D.) and Larger: Flanged copper alloy.

2.3 JOINING MATERIALS

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joining materials not in this Section.

B. Brazing Filler Metals: AWS A5.8, BCuP series alloys. Flux is prohibited unless used with bronze fittings.

C. Threaded-Joint Tape: PTFE.

D. Gasket Material: ASME B16.21, nonmetallic, flat, asbestos free, and suitable for oxygen service.

2.4 MEDICAL GAS VALVES

A. Valves, General: Factory cleaned for oxygen service and bagged. Color-coded handles and identification labels shall be provided with each valve.

1. Exception: Factory cleaning and bagging are not required for valves for WAGD service.

B. Copper-Alloy Ball Valves: MSS SP-110, 3-piece-body, full-port ball valve rated for 300-psig minimum working pressure; with chrome-plated brass ball, PTFE or TFE seats, blowout-proof stem, threaded or solder-joint ends, and locking-type handle designed for quarter turn between opened and closed positions.

C. Bronze Check Valves: Straight-through-pattern, spring-loaded ball check valve; designed for 300-psig minimum working pressure.

D. Zone Valves: MSS SP-110, 3-piece-body, full-port copper-alloy ball valve rated for 300-psig minimum working pressure; with chrome-plated brass ball, PTFE or TFE seats, blowout-proof stem, threaded or solder-joint ends, and handle designed for quarter turn between opened and closed positions.

1. Include union-type body with bolted swing-away center section.
2. Include factory-installed ASTM B 819, Type K or L, copper-tube extensions with pressure gage for pressure systems and vacuum gage for vacuum systems.

E. Zone Valve Boxes: Formed steel for recessed mounting, with holes for medical gas piping and anchors. Include boxes for single- or multiple-valve installation with pressure gage and in sizes to permit manual operation of valves.

1. Interior Finish: Factory-applied white enamel.
2. Cover Plate: Anodized aluminum with frangible or removable windows.
3. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

F. Emergency Medical Gas Connections: Low-pressure medical gas inlet assemblies for connection to building medical gas piping systems.

1. Emergency Oxygen Connection: Include the following:

   a. Enclosure: Weatherproof hinged locking cover with caption similar to "Emergency Low-Pressure Gaseous Oxygen Inlet."
   b. Inlet: Factory-installed, NPS 1 or NPS 1-1/4 (1-1/8" O.D. or 1-3/8" O.D.), ASTM B 819, copper tubing with NPS 1 (1-1/8" O.D.) minimum ball valve and plugged inlet.
   c. Safety Valve: Bronze-body, pressure relief valve set at 75 or 80 psig. Safety valve may be separate for installation in oxygen piping system.
   d. Instrumentation: Pressure gage.

2. Emergency Nitrous Oxide Connection: Include the following:

   a. Enclosure: Weatherproof hinged locking cover with caption similar to "Emergency Low-Pressure Gaseous Nitrous Oxide Inlet."
   b. Inlet: Factory-installed, NPS 1 or NPS 1-1/4 (1-1/8" O.D. or 1-3/8" O.D.), ASTM B 819, copper tubing with NPS 1 (1-1/8" O.D.) minimum ball valve and plugged inlet.
   c. Safety Valve: Bronze-body, pressure relief valve set at 75 or 80 psig. Safety valve may be separate for installation in oxygen piping system.
   d. Instrumentation: Pressure gage.

G. Safety Valves: Bronze body with settings to match system requirements.

1. Pressure Relief Valves: ASME construction, poppet type.
2. Vacuum Relief Valves: Specialty manufacturer's option.

H. Pressure Regulators: Bronze body and trim; spring-loaded, diaphragm-operated, relieving type; manual pressure-setting adjustment; rated for 250-psig minimum inlet pressure; and capable of controlling delivered air pressure within 0.5 psig for each 10-psig inlet pressure.

I. Automatic Drain Valves: Corrosion-resistant metal body and internal parts, 200-psig minimum working-pressure rating, and capable of automatic discharge of collected condensate.

2.5 MEDICAL GAS MANIFOLDS

A. Description: Manifolds for medical gases that comply with NFPA 99, Ch. 4, Section "Cylinder Systems without Reserve Supply," for high-pressure medical gas cylinders. Include the following features:

1. Central Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, pressure changeover switch, line-pressure regulator, shutoff valves, and safety valve.
2. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for 2000-psig minimum inlet pressure, except nitrous oxide manifolds may be designed for 800 psig and carbon dioxide manifolds may be designed for 1500 psig. Include cylinder bank headers with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
3. Medical Gas Cylinders: [**Will be furnished by Owner**] [**Furnish number and type of medical gas cylinders required for complete manifold systems**] <**Insert other**>.
4. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder bank header.
5. Mounting: [**Wall with mounting brackets for manifold control cabinet and headers**] [**Floor with support legs for manifold control cabinet**].
6. Label manifold control unit with permanent label identifying medical gas type and system operating pressure.
7. Nitrous Oxide Manifolds: For [**8 cylinders and 1333-cu. ft./h (10.5-L/s)**] [**12 cylinders and 2000-cu. ft./h (15.7-L/s)**] <**Insert other**> capacity at 55-psig (380-kPa) line pressure, with electric heater or orifice design that will prevent freezing during high demand.
8. Nitrogen Manifolds: For [**8 cylinders and 2000-cu. ft./h (15.7-L/s)**] [**12 cylinders and 3000-cu. ft./h (23.6-L/s)**] <**Insert other**> capacity at [**180-psig (1240-kPa)**] <**Insert other**> line pressure.
9. Oxygen Manifolds: For [**12 cylinders and 1500-cu. ft./h (11.8-L/s)**] [**20 cylinders 2500-cu. ft./h (19.7-L/s)**] <**Insert other**> capacity at 55-psig (380-kPa) line pressure.

10. Medical Air Manifolds: For [**4 cylinders and 1250-cu. ft./h (9.85-L/s)**] [**8 cylinders and 2500-cu. ft./h (19.7-L/s)**] <**Insert other**> capacity at 55-psig (380-kPa) line pressure.
11. Carbon Dioxide Manifolds: For [**2 cylinders and 250-cu. ft./h (1.97-L/s)**] [**4 cylinders and 500-cu. ft./h (3.94-L/s)**] <**Insert other**> capacity at 55-psig (380-kPa) line pressure.
12. High-Pressure Air Manifolds: For [**8 cylinders and 2000-cu. ft./h (15.7-L/s)**] [**12 cylinders and 3000-cu. ft./h (23.6-L/s)**] <**Insert other**> capacity at [**180-psig (1240-kPa)**] <**Insert other**> line pressure.

2.6 MEDICAL GAS SERVICE CONNECTIONS

A. Connection Devices: For specific medical gas pressure and vacuum services listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping, unless otherwise indicated.

1. Roughing-in Assembly:

   a. Steel outlet box for recessed mounting and concealed piping.
   b. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
   c. Double seals that will prevent gas leakage.
   d. ASTM B 819, Type K, NPS 3/8 (1/2" O.D.) copper inlet or outlet tube brazed to valve with gas-service marking and tube-end dust cap.

2. Finishing Assembly:

   a. Brass housing with primary check valve.
   b. Double seals that will prevent gas leakage.
   c. Cover plate with gas-service label.

3. Quick-Connect Service Connections: With keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use. Include the following:

   a. Oxygen Service Connections: Keyed oxygen outlet.
   b. Medical Air Service Connections: Keyed medical air outlet.
   c. Nitrous Oxide Service Connections: Keyed nitrous oxide outlet.
   d. Carbon Dioxide Service Connections: Keyed carbon dioxide outlet.
   e. Medical Vacuum Service Connections: Keyed medical vacuum suction inlet.
   f. Medical Vacuum Slide Brackets: With pattern matching medical vacuum service connection.
   g. WAGD Service Connections: Keyed WAGD suction inlet.
   h. <**Insert medical gas**> Service Connections: Keyed <**Insert description**>.

4. D.I.S.S Service Connections: CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.

a. Oxygen Service Connections: CGA V-5, D.I.S.S. No. 1240, oxygen outlet.
b. Medical Air Service Connections: CGA V-5, D.I.S.S. No. 1160, medical air outlet.
c. Nitrous Oxide Service Connections: CGA V-5, D.I.S.S. No. 1040, nitrous oxide outlet.
d. Carbon Dioxide Service Connections: CGA V-5, D.I.S.S. No. 1080, carbon dioxide outlet.
e. Medical Vacuum Service Connections: CGA V-5, D.I.S.S. No. 1220, medical vacuum suction inlet.
f. Medical Vacuum Slide Brackets: With pattern matching medical vacuum service connection.
g. WAGD Service Connections: CGA V-5, D.I.S.S. No. 2220, WAGD suction inlet.
h. Nitrogen Service Connections: CGA V-5, D.I.S.S. No. 1120, nitrogen outlet.
i. **<Insert medical gas>** Service Connections: CGA V-5, D.I.S.S. No. **<Insert number and description>**.

5. Wall Outlet Service Connection Cover Plates: One piece, [**stainless steel, with NAAMM AMP 503, No. 4 finish**] [**metal, with chrome-plated finish**] [**anodized aluminum**] and permanent, color-coded, medical gas identifying label matching corresponding outlets.
6. Vacuum Bottle-Slide Brackets: Bottle-slide and mounting assembly matching pattern of vacuum inlet. Include one slide bracket for each wall-mounting vacuum inlet unless no slide bracket requirement is indicated.

2.7 MEDICAL GAS PRESSURE CONTROL PANELS

A. Description: Steel box and support brackets for recessed roughing-in with stainless-steel or anodized-aluminum cover plate with printed operating instructions. Include manifold assembly consisting of inlet supply valve, inlet supply pressure gage, line-pressure control regulator, outlet supply pressure gage, D.I.S.S. service connection, and piping outlet for remote service connection.

1. Minimum Working Pressure: [**180 psig**] **<Insert other>**.
2. Line-Pressure Control Regulator: Self-relieving, diaphragm type with precision manual adjustment.
3. Pressure Gages: 0- to 300-psig range.
4. Before final assembly, provide temporary dust shield and U-tube for testing.
5. Air Control Panels: Label cover plate "Air Pressure Control." Include CGA V-5, D.I.S.S. No. 1160, high-pressure air outlet.
6. Nitrogen Control Panels: Label cover plate "Nitrogen Pressure Control." Include CGA V-5, D.I.S.S. No. 1120, nitrogen outlet.

2.8 MEDICAL GAS SERVICE UNITS

A. Medical Gas Service Units, General: Ceiling-mounting units with medical gas service connections as specified in Part 2 "Medical Gas Service Connections" Article Include labels indicating services, and the following:

1. Ceiling-Mounting Plate: Manufacturer's standard, field-fabricated plate or roughing-in assembly complying with unit manufacturer's written instructions.
2. Exposed Surfaces: Minimum 0.0375-inch- thick stainless steel with NAAMM AMP 503, No. 4 directional polish.
3. Servicing: Include access panels or means of removing shroud.
4. Blank cover plates for cutouts not having service connections.
5. ASTM B 819, Type K or L, NPS 3/8 (5/8" O.D.) copper-tube extensions for connection to medical gas systems.
6. Service Connections: Type and number indicated.
7. Dust Covers: For medical gas service connection.

B. Rigid Ceiling Service Columns: [**44-inch- <Insert other>** long, rectangular fixed column section with [**2**] **<Insert other>** double IV hooks. Include 0.078-inch- thick, stainless-steel bottom plate with the following service connections:

1. Oxygen: [**Two**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] outlets.
2. Medical Air: [**One**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] outlet(s).
3. Nitrous Oxide: [**One**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] outlet(s).
4. Carbon Dioxide: [**One**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] outlet(s).
5. Medical Vacuum: [**Two**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] inlets.
6. WAGD: [**One**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] inlet(s).
7. High-Pressure Air: [**One**] **<Insert other>** D.I.S.S. inlet(s).
8. Nitrogen: [**One**] **<Insert other>** D.I.S.S. inlet(s).
9. **<Insert medical gas>**: **<Insert number and type>**.
10. Power: [**2**] **<Insert other>** L5-20R, locking-type, 20-A, single, power receptacles.
11. Patient Equipment: [**2**] **<Insert other>** ground-jack, single-pole, 30-A receptacles.

C. Retractable Ceiling Service Columns: Manually adjustable using release and lock handles capable of locking column in all positions from fully retracted to fully extended; [**15-inch**] long, rectangular counterbalanced telescoping section with [**2**] **<Insert other>** double IV hooks; and [**36-inch-**] long, fixed column section. Include 0.078-inch- thick, stainless-steel bottom plate with the following service connections:

1. Oxygen: [**Two**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] outlets.
2. Medical Air: [**One**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] outlet(s).
3. Nitrous Oxide: [**One**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] outlet(s).
4. Carbon Dioxide: [**One**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] outlet(s).
5. Medical Vacuum: [**Two**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] inlets.
6. WAGD: [**One**] **<Insert other>** [**quick-connect**] [**D.I.S.S.**] inlet(s).
7. High-Pressure Air: [**One**] **<Insert other>** D.I.S.S. inlet(s).
8. Nitrogen: [**One**] **<Insert other>** D.I.S.S. inlet(s).
9. **<Insert medical gas>**: **<Insert number and type>**.
10. Power: [**2**] **<Insert other>** L5-20R, locking-type, 20-A, single, power receptacles.
11. Patient Equipment: [**2**] **<Insert other>** ground-jack, single-pole, 30-A receptacles.

D. Hose-Reel Service Assemblies: Individual, concealed, retractable hose-reel units with stainless-steel face plates, steel mounting boxes, factory- or field-fabricated mounting brackets, and color-coded service hoses with adjustable stops and service connections matching hoses. Include [**15 feet**] **<Insert other>** minimum of conductive CR 1/4- or 5/16-inch- ID medical gas hoses rated for 200-psig minimum working pressure, and the following service connections:

1. Oxygen Hose: [**Quick-connect**] [**D.I.S.S.**] outlet.
2. Medical Air Hose: [**Quick-connect**] [**D.I.S.S.**] outlet.
3. Nitrous Oxide Hose: [**Quick-connect**] [**D.I.S.S.**] outlet.
4. Carbon Dioxide Hose: [**Quick-connect**] [**D.I.S.S.**] outlet.
5. Medical Vacuum Hose: [**Quick-connect**] [**D.I.S.S.**] inlet.
6. WAGD Hose: [**Quick-connect**] [**D.I.S.S.**] inlet.
7. High-Pressure Air Hose: D.I.S.S. inlet.
8. Nitrogen Hose: D.I.S.S. inlet.
9. <**Insert medical gas**> Hose: <**Insert number and type**>.
10. Power: L5-20R, locking-type, 20-A, single, power receptacle.

E. Fixed Hose Service Assemblies: Individual, concealed hose connection with stainless-steel face plates, steel mounting boxes, factory- or field-fabricated mounting brackets, and color-coded service hoses with retractor device and service connections matching hoses. Include [**72 inches**] <**Insert other**> of conductive CR 1/4- or 5/16-inch- ID medical gas hoses rated for 200-psig minimum working pressure, and the following service hose connections:

1. Oxygen Hose: [**Quick-connect**] [**D.I.S.S.**] outlet.
2. Medical Air Hose: [**Quick-connect**] [**D.I.S.S.**] outlet.
3. Nitrous Oxide Hose: [**Quick-connect**] [**D.I.S.S.**] outlet.
4. Carbon Dioxide Hose: [**Quick-connect**] [**D.I.S.S.**] outlet.
5. Medical Vacuum Hose: [**Quick-connect**] [**D.I.S.S.**] inlet.
6. WAGD Hose: [**Quick-connect**] [**D.I.S.S.**] inlet.
7. High-Pressure Air Hose: D.I.S.S. inlet.
8. Nitrogen Hose: D.I.S.S. inlet.
9. <**Insert medical gas**> Hose: <**Insert number and type**>.
10. Power: L5-20R, locking-type, 20-A, single, power receptacle.

2.9 MEDICAL GAS ALARM SYSTEM

A. Medical Gas Alarm System, General: Compatible alarm panels, remote sensing devices, and other related components as required by NFPA 99 for Level [**1**] medical gas alarm systems. Refer to Division 15 Section "Medical Air and Vacuum Equipment" for air compressors and vacuum pumps. Power wiring is specified in Division 16 Sections.

B. Components: Designed for continuous service and to operate on power supplied from 120-V ac power source to alarm panels and with connections for 24- or 12-V ac low-voltage wiring to remote sensing devices. Include step-down transformers if required.

C. Dew Point Monitors: Continuous line monitoring, having panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, factory- or field-installed valved bypass, and visual and cancelable audio signal for dryer site and master alarm panels. Alarm signals when pressure dew point rises above 39 deg F at 55 psig.

1. Operation: [**Chilled-mirror method**] [**Chilled-mirror method or hygrometer moisture analyzer with sensor probe**] [**Hygrometer moisture analyzer with sensor probe**].

D. Pressure and Vacuum Switches or Pressure Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.

1. Low-Pressure Switches: 0- to 100-psig operating range.
2. High-Pressure Switches: Up to 250-psig operating range.
3. Vacuum Switches: 0- to 30-in. Hg range.

E. Carbon Monoxide Monitors: Panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, and factory- or field-installed valved bypass. Alarm signals when carbon monoxide level rises above 10 ppm.

F. Medical Gas Alarm Panels: Factory wired with audible and color-coded visible signals to indicate specified functions.

1. Mounting: **[Exposed, surface]** [**Recessed**] installation.
2. Enclosures: Fabricated from minimum 0.047-inch- thick steel or minimum 0.05-inch-(1.27-mm-) thick aluminum, with knockouts for electrical and piping connections.
3. Anesthetizing-Area Alarm Panels: Separate trouble alarm signals; pressure and vacuum gages; and indicators for oxygen, medical air, medical vacuum, nitrous oxide, nitrogen, WAGD, carbon dioxide, and high-pressure air. Alarm signals when the following conditions exist:

   a. Oxygen: Pressure drops below 40 psig or rises above 60 psig.
   b. Medical Air: Pressure drops below 40 psig or rises above 60 psig.
   c. Medical Vacuum: Vacuum drops below 12 in. Hg.
   d. Nitrous Oxide: Pressure drops below 40 psig or rises above 60 psig.
   e. Nitrogen: Pressure drops below [**160 psig**] <**Insert other**> or rises above [**200 psig**] <**Insert other**>.
   f. WAGD: Vacuum drops below 12 in. Hg.
   g. Carbon Dioxide: Pressure drops below 40 psig or rises above 60 psig.
   h. High-Pressure Air: Pressure drops below [**160 psig**] <**Insert other**> or rises above [**200 psig**] <**Insert other**>.

4. Area Alarm Panels: Separate trouble alarm signals; pressure and vacuum gages; and indicators for oxygen, medical air, and medical vacuum. Alarms signal when the following conditions exist:

   a. Oxygen: Pressure drops below 40 psig or rises above 60 psig.
   b. Medical Air: Pressure drops below 40 psig or rises above 60 psig.
   c. Medical Vacuum: Vacuum drops below 12 in. Hg.

5. Local Alarm Panels: Separate trouble alarm signals and pressure and vacuum gages to indicate function of medical gas and vacuum equipment. Include alarm signals at local alarm panels when the following conditions exist:

   a. Medical Air Equipment: Pressure drops below 40 psig or rises above 60 psig, backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig, dew point rises above 39 deg F at 55 psig, carbon monoxide level rises above 10 ppm, and high water level is reached in receiver for liquid-ring, medical air compressor systems.

b. Medical Vacuum Equipment: Vacuum drops below 12 in. Hg and backup vacuum pump is in operation.

6. Master Alarm Panels: Separate trouble alarm signals, pressure and vacuum gages, and indicators for oxygen, medical air, medical vacuum, nitrous oxide, nitrogen, WAGD, carbon dioxide. Include alarm signals at master alarm panels when the following conditions exist:

   a. Oxygen: Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig or rises above 60 psig, changeover is made to reserve, reserve is in use, reserve level is low, and reserve pressure is low.
   b. Oxygen: Pressure downstream from main shutoff valve drops below 40 psig or rises above 60 psig and changeover is made to alternate bank.
   c. Medical Air: Pressure drops below 40 psig or rises above 60 psig, backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig, dew point rises above 39 deg F at 55 psig, carbon monoxide level rises above 10 ppm, and high water level is reached in receiver for liquid-ring, medical air compressor systems.
   d. Medical Vacuum: Vacuum drops below 12 in. Hg and backup vacuum pump is in operation.
   e. Nitrous Oxide: Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig or rises above 60 psig, changeover is made to reserve, reserve is in use, and reserve level is low.
   f. Nitrous Oxide: Pressure drops below 40 psig or rises above 60 psig and changeover is made to alternate bank.
   g. Nitrogen: Pressure drops below 160 psig or rises above 200 psig and changeover is made to alternate bank.
   h. WAGD: Vacuum drops below 12 in. Hg.
   i. Carbon Dioxide: Pressure drops below 40 psig or rises above 60 psig and changeover is made to alternate bank.

7. Computer Interface Cabinet: Wall-mounting, welded-steel, control cabinet with gasketed door, mounting brackets, grounding device, and white-enamel finish for connection of medical gas system alarms to facility computer. Include factory-installed signal circuit boards, power transformer, circuit breaker, wiring terminal board, and internal wiring capable of interfacing [**20**] <**Insert other**> alarm signals.

2.10 MEDICAL GAS CYLINDER STORAGE RACKS

A. Wall Storage Racks for Medical Gas Cylinders: Fabricate racks with chain restraints for upright gas cylinders as indicated or provide equivalent manufactured wall racks.

B. Freestanding Storage Racks for Medical Gas Cylinders: Fabricate racks for gas cylinders as indicated or provide equivalent manufactured storage racks.

2.11 TEST GAS

A. Description: Oil-free dry nitrogen complying with CGA P-9, for purging and testing of piping.

2.12 IDENTIFICATION

A. Refer to Division 15 Section "Mechanical Identification" for identification of piping, valves, gages, alarms, and specialties and for labels for bulk medical gas storage tanks.

PART 3 - EXECUTION

3.1 PREPARATION

A. Interruption of Existing Medical Gas Service:

1. Contractor shall not interrupt medical gas service to occupied facilities. Under no conditions shall medical gas service valves (existing or new) be closed by the Contractor.
2. Owner shall be responsible for isolating portions of existing systems and closing service valves as required; including verifying proper service valve or zone valve labeling, and exact areas and rooms controlled.

B. Medical Gas System Isolation:

1. Total isolation between new systems and existing systems shall be maintained until all new piping is tested for leaks and tested for cross connections per NFPA 99 by the Contractor.

C. Cleaning of Piping: If precleaned piping must be recleaned because of exposure, perform the following procedures:

1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."
2. Wash medical gas piping and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.

a. Scrub to ensure complete cleaning.
b. Rinse with clean, hot water to remove cleaning solution.

3.2 EARTHWORK

A. Refer to Division 2 Section "Earthwork" for excavating, trenching, and backfilling.

3.3 CONCRETE BASES

A. Install concrete bases for [**medical gas manifolds**] [**bulk medical gas storage tanks**] [**medical gas manifolds and bulk storage tanks**] <**Insert other**>. Cast anchor-bolt inserts into bases. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for concrete bases and

to Division 3 Section "[**Cast-in-Place Concrete**] [**Cast-in-Place Concrete (Limited Applications)**]" for formwork, reinforcement, and concrete requirements.

3.4 PIPING APPLICATIONS

A. General: Use pipe, tube, fittings, and joining methods for medical gas piping systems according to the following applications:

B. Joining New to Existing Copper Tubes [**NPS 2 (2-1/8" O.D.)**] <**Insert other**> and Smaller: Use memory-metal couplings.

C. Joining of Dissimilar Metal Piping: Use dielectric fittings. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for dielectric fitting types.

1. NPS 2 (2-1/8" O.D.) and Smaller: Use dielectric unions.
2. NPS 2-1/2 to NPS 4 (2-5/8" to 4-1/8" O.D.): Use dielectric flanges.
3. NPS 5 (5-1/8" O.D.) and Larger: Use dielectric flange kits.

D. Specialty and Equipment Flanged Connections: Use cast-copper-alloy companion flange with gasket and brazed joint for connection to copper tube.

E. Interior[**and Underground**] Medical Gas Pressure Piping: Use hard copper tube, copper pressure fittings, and brazed joints.

F. Interior[**and Underground**] Medical Gas Piping at Pressures Greater Than 200 psig: Use ASTM B 819, Type K, hard copper tube, copper pressure fittings, and brazed joints.

G. Interior Medical Vacuum Piping: Use hard copper tube, copper pressure fittings, and brazed joints.

H. Interior WAGD Piping: Use hard copper tube, copper pressure fittings, and brazed joints.

I. Underground Protective Conduit: [**Schedule 40, PVC pipe; Schedule 40**] [**Schedule 80, PVC pipe; Schedule 80**], PVC pressure fittings; and solvent-cemented joints.

3.5 MEDICAL GAS VALVE APPLICATIONS

A. Drawings indicate medical gas valve types to be used. If specific valve types are not indicated, the following requirements apply:

1. Medical Gas Pressure Piping:

   a. Shutoff Valves NPS 3 (3-1/8" O.D.) and Smaller: Copper-alloy ball valve.
   b. Check Valves NPS 3 (3-1/8" O.D.) and Smaller: Bronze.

2. Medical Vacuum Piping:

   a. Shutoff Valves NPS 3 (3-1/8" O.D.) and Smaller: Copper-alloy ball valve.
   b. Check Valves NPS 3 (3-1/8" O.D.) and Smaller: Bronze.

3. WAGD Piping:

   a. Shutoff Valves NPS 3 (3-1/8" O.D.) and Smaller: Copper-alloy ball valve.
   b. Check Valves NPS 3 (3-1/8" O.D.) and Smaller: Bronze.

4. Zone Valves: With copper-tube extensions and gage.

3.6 PIPING INSTALLATION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation.

B. Install supports and anchors according to Division 15 Section "Hangers and Supports" with spacing according to NFPA 99.

C. Install thermometers and pressure gages according to Division 15 Section "Meters and Gages."

D. Install flexible pipe connector at each connection to medical air and vacuum equipment.

E. Install exterior, buried medical gas piping in protective conduit fabricated with PVC pipe and fittings. Do not extend conduit through foundation wall.

F. Purge medical gas piping, using oil-free dry nitrogen, after installing piping but before connecting to service connections, alarms, and gages.

3.7 MEDICAL GAS VALVE INSTALLATION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping and valve installation.

B. Install valves in locations required by and according to NFPA 99.

C. Install valves as required for phasing, purging, and testing. Remove handles or lock open as required.

D. Install shutoff valve at each connection to and from medical gas specialties and equipment.

E. Install check valves to maintain correct direction of fluid flow to and from medical gas specialties and equipment.

F. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

G. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

1. Pressure System Valves: Install pressure gage downstream from valve.
2. Suction System Valves: Install vacuum gage upstream from valve.

H. Install pressure safety and vacuum relief valves where recommended by specialty manufacturers.

I. Install emergency medical gas connections with pressure relief valve and full-size discharge piping to outside, with check valve downstream from pressure relief valve and with ball valve and check valve in supply main from bulk oxygen storage tank.

J. Install pressure regulators in piping to reduce pressure.

K. Install automatic drain valves for specialties and medical air and vacuum equipment that require draining.

3.8 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. Brazed Joints: Use silver- or copper-phosphorus-composition filler metal and comply with CDA's "Copper Tube Handbook," Section VII, "Brazed Joints"; or AWS D10.13, "Recommended Practices for the Brazing of Copper Pipe and Tubing for Medical Gas Systems."

C. Arrange for coupling manufacturer's authorized representative to join new copper tube to existing copper tube with memory-metal couplings.

D. Join new copper tube to existing copper tube with memory-metal couplings. Follow coupling manufacturer's product-specific procedure.

3.9 MEDICAL GAS MANIFOLD INSTALLATION

A. Install medical gas manifolds[**on concrete base**] anchored to substrate.

B. Install medical gas cylinders and connect to manifold piping.

C. Install medical gas manifolds with seismic restraints as indicated.

3.10 MEDICAL GAS SERVICE CONNECTION INSTALLATION

A. Install medical gas service connections, of types indicated, in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

B. Install medical gas service connections, of types indicated, in medical gas service units.

3.11 ELECTRICAL SERVICE CONNECTION INSTALLATION

A. Install electrical service connections, of types indicated, in medical gas service units.

3.12 MEDICAL GAS SERVICE UNIT INSTALLATION

A. Install ceiling-mounting service units anchored to substrate according to manufacturer's written instructions. Provide structural steel, hanger rods, anchors, and fasteners in addition to components furnished with specialties necessary to fabricate supports.

3.13 MEDICAL GAS ALARM SYSTEM INSTALLATION

A. Install medical gas alarm system components in locations required by and according to NFPA 99 and manufacturer's written instructions.

B. Install medical gas alarm panels[**and computer interface cabinet**] where indicated.

C. Install medical gas anesthetizing-area, area, and master alarm panels.

D. Install medical gas local alarm panels at source equipment.

E. Install computer interface cabinet with connection to medical gas alarm system.

3.14 MEDICAL GAS CYLINDER STORAGE RACK INSTALLATION

A. Install medical gas cylinder storage racks as indicated.

3.15 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to specialties and equipment to allow service and maintenance.

C. Connect medical gas piping to specialties, equipment, and accessories.

1. Connection NPS 2 (2-1/8" O.D.) and Smaller: With shutoff valve and copper union.
2. Connection NPS 2-1/2 (2-5/8" O.D.) and Larger: With shutoff valve and cast-copper-alloy flange.

D. Ground specialties and equipment according to Division 16 Section "Grounding and Bonding."

E. Connect wiring according to Division 16 Section "Conductors and Cables."

F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.16 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for medical gas piping systems according to NFPA 99. Refer to Division 15 Section "Mechanical Identification" for labeling and identification materials.

B. Captions and Color-Coding: Use the following or similar medical gas captions and color-coding for medical gas piping products where required by NFPA 99:

1. Oxygen: White letters on green background or green letters on white background.
2. Medical Air: Black letters on yellow background.
3. Nitrous Oxide: White letters on blue background.
4. Nitrogen: White letters on black background.
5. Carbon Dioxide: Black or white letters on gray background.
6. Medical Vacuum: Black letters on white background.
7. WAGD: White letters on purple background.

C. Label medical gas systems operating at other-than-standard pressure with system operating pressure.

D. Install continuous detectable underground warning tapes during backfilling of trenches for exterior underground medical gas piping. Locate tapes below finished grade, directly over piping. Refer to Division 2 Section "Earthwork" for underground warning tapes.

3.17 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Testing Agency: Contractor shall engage a qualified independent testing and inspecting agency to perform the following field tests and inspections and prepare test reports. The Testing Agency shall be approved by the Owner.

1. Inspect, test, and certify completed medical gas systems according to requirements in NFPA 99. Inspect, test, and certify each medical gas piping system, including specialties, service connections, alarm system, safety devices, and source equipment.

2. Inspect, test, and Re-Certify zones or portions of the existing medical gas and vacuum systems downstream of where connections or modifications to the existing systems are made.

3. Provide oil-free dry nitrogen, medical gases, materials, and equipment required for testing.
4. Level 1 Pressure Medical Gas Testing: Use oil-free dry nitrogen, unless otherwise indicated, and perform procedures and tests as indicated in NFPA 99 performance and testing paragraphs for piped gas systems. Include the following:

a. Performance Testing:

1) Blow Down: Clear piping before connecting service connections or outlets.
2) Initial Pressure Tests: Subject each piping section to test pressure of 1.5 times system working pressure, but not less than 150 psig, before attaching system components, after installing station outlets with test caps (if supplied) in place, and before concealing piping system. Maintain test until joints are examined for leaks by means of soapy water. Repair leaks with new materials and retest systems.
3) Cross-Connection Tests: Determine that no cross connections of piping systems exist. Disconnect all systems except system to be checked. Pressurize system to 50 psig. Verify that gas flow from service connections and outlets is only from system being checked. Repeat for each system. Verify correct labeling.
4) Purge Tests: Perform heavy intermittent purging of piping and full-flow purging of service connections.
5) Standing-Pressure Tests: Install assembled system components after testing individual systems as specified above. Subject systems to 24-hour standing-pressure test at 20 percent above normal line pressure. Verify that pressure differences comply with required calibration. Repair leaks with new materials and retest systems.

b. System Verification:

1) Cross-Connection Tests: Repeat cross-connection test above or perform alternate tests with each gas at different pressure.
2) Flow Tests: Perform flow test at each outlet.
3) Valve Tests: Verify proper valve operation.
4) Alarm Tests: Operate systems and verify proper warning indication of each medical gas piping system function.
5) Piping Purity Tests: Test for dew point and hydrocarbons as compared to source gas.
6) Final Tie-End Tests: Verify that above tests have been successfully performed.
7) Operational Pressure Tests: Use designated system gases and test for pressure and flow.
8) Medical Gas Concentration Tests: Test each gas for required concentration.
9) Labeling: Verify correct labeling.

5. Level 1 Vacuum System Testing: Use oil-free dry nitrogen, unless otherwise indicated, and perform procedures and tests as indicated in NFPA 99 performance and testing paragraphs for piped vacuum systems. Include the following:

a. Blow Down: Clear piping before connecting service connections or inlets.
b. Initial Pressure Tests: Subject each piping section to test pressure not less than 150 psig before attaching system components, after installing station outlets with test caps (if supplied) in place, and before concealing piping system. Maintain test until joints are examined for leaks by means of soapy water. Repair leaks with new materials and retest systems.
c. Initial Cross-Connection Tests: Determine that no cross connections of piping systems exist. Disconnect all systems except system to be checked. Pressurize

system to 50 psig. Verify that gas flow from service connections and outlets is only from system being checked. Repeat for each system. Verify correct labeling.

d. Standing-Pressure Tests: Install assembled system components after testing individual systems as specified above. Subject systems to 24-hour standing-pressure test at not less than 60 psig.
e. Final Cross-Connection Tests: Repeat cross-connection test above or perform alternate tests with each system at different pressure.
f. Vacuum Tests: Verify functional operation of components.
g. Valve Tests: Verify proper valve operation.
h. Alarm Tests: Operate systems and verify proper warning indication of each medical gas piping system function.
i. Labeling: Verify correct labeling.

C. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:

1. Inspections performed.
2. Procedures, materials, and gases used.
3. Test methods used.
4. Results of tests.

3.18 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain medical gas alarm system. Refer to Division 1 Section "**[Closeout Procedures] [Demonstration and Training]**."

END OF SECTION

SECTION 15410

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by this Section.

1.2 SUMMARY

A. This Section includes plumbing fixtures and related components.

B. Related Sections include the following:
1. Section 15430, "Plumbing Specialties" for water distribution piping specialties.

1.3 DEFINITIONS

A. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Fitting: Device that controls flow of water into or out of plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

C. ADA: Americans with Disabilities Act.

1.4 SUBMITTALS

A. Pre-Construction Submittals: Submit the following items prior to commencing with the installations.
1. Product Data: Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports and indicate materials and finishes, dimensions, construction details, and flow-control rates for each type of fixture indicated.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; about plumbing fixtures for people with disabilities.

B. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

C. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

D. Comply with the following applicable standards and other requirements specified for plumbing fixtures.
   1. Stainless-Steel Fixtures Other Than Service Sinks: ASME A112.19.3M.

E. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
   1. Faucets: ASME A112.18.1M.
   2. NSF Materials: NSF 61.
   3. Pipe Threads: ASME B1.20.1.
   4. Supply and Drain Fittings: ASME A112.18.1M.

1.6 COORDINATION

A. Coordinate roughing-in and final plumbing fixture locations, and verify that fixtures can be installed to comply with original design and referenced standards.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. Stainless Steel Sinks:
   1. Just Mfg. Co.
   2. Elkay Mfg. Co.
   3. Kindred.

2.2 FIXTURES, GENERAL

A. General fixture, faucet and related item requirements are listed below. Refer to the "Plumbing Fixture Schedule" on the Drawings for the basis of design for each item.

B. Accessibility: Fixtures and items that are required to be accessible are tagged as such in the Plumbing Fixture Schedule on the Drawings.

2.3 FAUCETS

A. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.

1. Maximum Flow Rate, (unless otherwise indicated):
   a. Sinks: 2.5 gpm.
2. Body Material: Cast brass
3. Finish: Polished chrome plate.

2.4 PROTECTIVE SHIELDING GUARDS

A. General: Manufactured insulation and plastic covering for water supply, trap and drain piping and complying with ADA requirements.

2.5 SUPPLY STOPS

A. General: Cast brass or copper, chrome plated angle style with chrome plated escutchon and loose key operator.
1. Lavatory Supplies: NPS 3/8.
2. Sink and Tank Style Water Closet Supplies: NPS ½.

2.6 GENERAL USE SINKS

A. General: Commercial, counter mount, self rimming, sound deadening fixture.
1. Material: 18 gauge, type 304 stainless steel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water soil and for waste piping systems to verify actual locations and sizes of piping connections and that locations and types of supports match those indicated, before plumbing fixture installation. Use manufacturer's roughing-in data if roughing-in data are not indicated.

B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.

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

3.2 FIXTURE INSTALLATION

A. Assemble fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install counter-mounting fixtures in and attached to casework.

C. Install fixtures level and plumb according to manufacturers' written instructions and roughing-in drawings.

D. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball, gate, or globe valve if stops are not specified with fixture.

E. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

F. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

G. Install protective shielding guards on exposed under counter supply and waste piping at fixtures identified as accessible and at other locations scheduled.

H. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

I. Install water-supply, flow-control fittings with specified flow rates in fixture supplies at stop valves.

J. Install faucet, flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

K. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

L. Install escutcheons at piping wall and ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for escutcheons.

M. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Refer to Division 7 Section "Joint Sealants" for sealant and installation requirements.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect water supplies from water distribution piping to fixtures.

C. Connect drain piping from fixtures to drainage piping.

D. Supply and Waste Connections to Plumbing Fixtures: Connect fixtures with water supplies, stops, risers, traps, and waste piping. Use size fittings required to match fixtures. Connect to plumbing piping.

E. Supply and Waste Connections to Fixtures and Equipment Specified in Other Sections: Connect fixtures and equipment with water supplies, stops, risers, traps, and waste piping specified. Use size fittings required to match fixtures and equipment. Connect to plumbing piping.

3.4 FIELD QUALITY CONTROL

A. Verify that installed fixtures are categories and types specified for locations where installed.

B. Check that fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow and stream.

C. Replace washers and seals of leaking and dripping faucets and stops.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 15430

PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by this Section.

1.2 SUMMARY

A. This Section includes the following plumbing specialties:
   1. Drain valves.
   2. Miscellaneous piping specialties.
   3. Cleanouts.

B. Related Sections include the following:

   1. Section 15122, "Meters and Gages" for water meters, (other than at municipal entrances), thermometers, and pressure gages.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. PE: Polyethylene plastic.

C. PUR: Polyurethane plastic.

D. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing piping systems with following minimum working-pressure ratings, unless otherwise indicated:
   1. Water Supply Systems, Above Ground: 125 psig.
   2. Water Supply Systems, Below Ground: 150 psig.

3. DWV, (Gravity) Systems: 10 foot of head of water.
4. DWV, (Forced Main) Systems: 100 psig.

1.5 SUBMITTALS

A. General: See Division 1 for general submittal and product substitution requirements.

B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.
1. Product Data, including wiring diagrams for electrically and battery powered items.
a. Cleanouts.
b. Water hammer arresters and air vents.
c. Drain valves.

1.6 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of plumbing specialties and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Plumbing specialties shall bear label, stamp, or other markings of specified testing agency.

C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for piping materials and installation.

D. NSF Compliance:
1. Comply with NSF 61, "Drinking Water System Components--Health Effects, Sections 1 through 9," for potable domestic water plumbing specialties.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. Water Hammer Arresters:
1. Josam Co.
2. Precision Plumbing Products, Inc.
3. Sioux Chief Manufacturing Co., Inc.
4. Watts Industries, Inc.
5. Smith, Jay R. Mfg. Co.
6. Zurn Industries, Inc.; Wilkins Div.

C. Cleanouts:
1. Watts Industries, Inc.

2. Smith, Jay R. Mfg. Co.
3. Zurn Industries, Inc.; Wilkins Div.
4. Josam Co.
5. Tyler Pipe; Wade Div.

2.2 DRAIN VALVES

A. Hose-End Drain Valves: MSS SP-110, NPS 3/4 (DN 20) ball valve, rated for 400-psig (2760-kPa) minimum CWP. Include two-piece, copper-alloy body with standard port, chrome-plated brass ball, replaceable seats and seals, blowout-proof stem, and vinyl-covered steel handle.

1. Inlet: Threaded or solder joint.
2. Outlet: Short-threaded nipple with ASME B1.20.7, garden-hose threads and cap.

2.3 WATER HAMMER ARRESTERS

A. General: ASSE 1010 or PDI-WH 201, piston type with pressurized metal-tube cushioning chamber. Sizes indicated are based on ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for piping joining materials, joint construction, and basic installation requirements.

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
4. Locate at base of each vertical soil and waste stack.

C. Install individual shutoff valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve is not indicated. Install shutoff valves in accessible locations. Refer to Division 15 Section "Valves" for general-duty ball, butterfly, check, gate, and globe valves.

D. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.3 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 15725

MODULAR INDOOR AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

A. This Section includes constant-volume, modular air-handling units with coils for indoor installations.

B. Related Sections include the following:

1. Division 15, Section 15071 "Mechanical Vibration and Seismic Controls".

1.3 SUBMITTALS

A. General: See Division 1 for general submittal and product substitution requirements.

B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.

1. Product Data: For each type of modular indoor air-handling unit indicated. Include the following:
   a. Certified fan-performance curves with system operating conditions indicated.
   b. Certified fan-sound power ratings.
   c. Certified coil-performance ratings with system operating conditions indicated.
   d. Motor ratings, electrical characteristics, and motor and fan accessories.
   e. Material gages and finishes.
   f. Filters with performance characteristics.
2. Shop Drawings:
   a. Wiring Diagrams: Power, signal, and control wiring.

C. Post Construction Submittals: Submit the following items upon completion of system installations.

1. Field Quality-Control Test Reports: From manufacturer.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of modular indoor air-handling units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

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

C. NFPA Compliance: Modular indoor air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

D. ARI Certification: Modular indoor air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

E. Comply with NFPA 70.

1.5 COORDINATION

A. Coordinate size and location of structural-steel support members.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. CES Group Inc.; Governair, Mammoth, Temtrol, Venmar Ventrol, Webco Divisions
2. Enviromental Technologies Inc.
3. Gaylord Industries, Inc.

2.2 MANUFACTURED UNITS

A. Modular indoor air-handling unit shall be factory assembled and consist of fan, motor and drive assembly, coils, access sections, filters, condensate pans, and accessories. Design based on Temptrol Model FC. Unit shall have overall dimensions as indicated and fit into the space available with adequate clearance for service as determined by the engineer.

2.3 CABINET

A. Materials: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

1. Outside Casing: 20 gauge galvanized steel, standing seam.
2. Inside Casing: 20 gauge galvanized steel.
3. 16 gauge G-90 galvanized steel top and bottom frame.

B. Cabinet Insulation: Comply with NFPA 90A or NFPA 90B.

1. Materials: 3 lb/ft^3 fiberglass.
2. Thickness: 2 inch (25 mm).
3. Thermal Conductivity (k-Value): 0.26 at 75 deg F (0.037 at 24 deg C) mean temperature.
4. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50, when tested according to ASTM C 411.
5. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and ASTM C 916.
6. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
7. Location and Application: Encased between outside and inside casing.

C. Access Panels and Doors: Two inch thick insulated, solid double wall, hinged access doors, complete with latches and gaskets. Inspection and access panels and doors shall be sized and located to allow periodic maintenance and inspections. Provide access panels and doors in the following locations:

1. Fan Section: Doors.
2. Access Sections: Doors, to allow access to coils and drain pan.
3. Filter Sections: Doors to allow periodic removal and installation of filters.

D. Condensate Drain Pans: Formed sections of 304 stainless steel complying with requirements in ASHRAE 62. Fabricate pans with slopes in two planes to collect condensate from cooling coils (including coil piping connections and return bends) when units are operating at maximum catalogued face velocity across cooling coil.

1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
2. Drain Connection: Stainless steel threaded connection.
3. Units with stacked coils shall have an intermediate drain pan or drain trough to collect condensate from top coil.

2.4 FAN SECTION

A. Fan-Section Construction: Direct drive plug fan consisting of housing, wheel, fan shaft, bearings, inverter-duty motor, drive assembly, and support structure and equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels. Mount fan with vibration isolation. Coordinate seismic restraint with Section 15071.

B. Fan wheel shall be fabricated from aluminum and keyed to the motor shaft. Fan shall be rated in accordance with AMCA 210 for performance and AMCA 300 for sound.

C. Centrifugal Fan Housings: Access doors or panels to allow entry to internal parts and components.

1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan, motor, and accessories.
2. Plug Fans: With steel cabinet. Fabricate without fan scroll and volute housing.

D. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower.
1. Fan bearings shall be self-aligning, non-regreasable type with an average life of 100,000 hours at design operation conditions, per AMSO Code B3.15.
2. Fan drive shall be designed at a minimum of 1.15 service factor and shall be factory mounted and aligned.

3. Shafts: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
   a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
   b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Vibration Control: Install fans on open-spring vibration isolators having a minimum of 1-inch (25-mm) static deflection. Coordinate seismic restraints with Section 15071.

F. Fan-Section Source Quality Control:
1. Unit sound data shall be per ARI 260 "Sound Rating of Ducted Air Moving and Conditioning Equipment".

2.5 MOTORS

A. Comply with requirements in Division 15, Section 15050 Basic Mechanical Materials and Methods, "Motors for Mechanical Equipment." Provide high efficiency motor.

2.6 ELECTRICAL

A. The fan motor shall be wired to an external mounted VFD furnished by the unit manufacturer.

2.7 COILS

A. Coil Sections: Design and construct to facilitate removal and replacement of coil for maintenance and to ensure full airflow through coils.

B. Water Coils: Drainable and cleanable coil fabricated according to ARI 410.

1. Piping Connections: Sweat connections.
2. Tubes: copper.
3. Fins: Aluminum.
4. Fin and Tube Joint: Mechanical bond.
5. Headers: Copper.
6. Frames: Stainless steel, 0.0625 inch (1.58 mm).
7. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.

a. Working-Pressure Ratings: 300 psig, 200 deg F.
b. Source Quality Control: Test to 450 psig, underwater.

2.8 FILTERS

A. Filters: Comply with NFPA 90A.

B. Filter Section: Provide filter holding frames arranged for flat or angular orientation. Filters shall be removable from one side.

C. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with holding frames.

1. Media: Interlaced glass fibers sprayed with nonflammable adhesive.

D. Prefilters: Pleated, 30% efficient of standard sizes.

E. HEPA Filters: Factory-fabricated HEPA filters with holding casing.
1. Media: UL 586, fibrous glass, constructed of continuous sheets with closely spaced pleats, 99.97% efficiency.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of hydronic and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Install modular indoor air-handling units with the following vibration and seismic-control devices. Seismic control devices are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

1. Units with Internally Isolated Fans: Secure units to anchor bolts installed in concrete bases.
2. Suspended Units: Suspend units from structural-steel support frame using threaded steel rods and spring hangers.

B. Arrange installation of units to provide access space around modular indoor air-handling units for service and maintenance.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to modular indoor air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4 (DN 32), Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping." Connect to supply and return coil tappings with shutoff or balancing valve and union or flange at each connection.

F. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories.

G. Electrical: Comply with applicable requirements in Division 16 Sections for power wiring, switches, and motor controls.

H. Ground equipment according to Division 16 Section "Grounding and Bonding."

I. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, fill water coils with water and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
3. HEPA Filter Operational Test: Pressurize housing to a minimum of 3-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.

3.5 STARTUP SERVICE

A. Final Checks before Startup: Perform the following:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Comb coil fins for parallel orientation.
7. Install clean filters.

B. Starting procedures for modular indoor air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
2. Measure and record motor electrical values for voltage and amperage.

C. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for modular indoor air-handling system testing, adjusting, and balancing.

3.6 CLEANING

A. Clean modular indoor air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. After completing system installation and testing, adjusting, and balancing modular indoor air-handling and air-distribution system, clean filter housings and install new filters.

END OF SECTION

SECTION 15752

HUMIDIFIERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

A. This Section includes the following type of humidifiers:

1. Heated pan humidifiers for application on ducted HVAC systems.

B. Related Sections include:
1. Section 15940 "Sequence of Operations".

1.3 SUBMITTALS

A. General: See Division 1 for general submittal and product substitution requirements.

B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.
1. Product Data: Include rated capacities, operating weights, furnished specialties, and accessories.
2. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, and dispersion tubes.
3. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
4. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, and required clearances.

C. Post Construction Submittals: Submit the following items upon completion of system installations.
1. Maintenance Data: For humidifiers to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

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

B. Comply with ARI 610, "Standard for Central System Humidifiers for Residential Applications."

C. Comply with ARI 620, "Standard for Self-Contained Humidifiers for Residential Applications."

D. Comply with ARI 640, "Standard for Commercial and Industrial Humidifiers."

1.5 COORDINATION

A. Coordinate location and installation of humidifiers in duct. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Heated-Pan Humidifiers:

a. Armstrong International, Inc.
b. Dri-Steem Humidifier Co.
c. Nortec Industries, Inc.
d. Pure Humidifier Co.

2.2 HEATED-PAN HUMIDIFIERS

A. Description: Evaporative heated-pan humidifier that generates water vapor from heated pan of water for distribution in airstream. Heat source shall be electricity. The humidifier shall be remotely mounted with connecting hose to dispersion unit in duct airstream. Humidifier shall be UL listed. Design based on DRISTEEM Humidifier Co., Model VLC.

B. Stainless steel construction: Vaporizing chamber, cover and fittings shall be constructed of stainless steel with heli-arc welded seams. Cover shall be secured by quick removal threaded knobs. The gasket shall be held in place by flanges that are formed as part of the cover and as part of the evaporating chamber. Flanges shall lock in sealing gasket.

C. Immersion Heater: Heater shall be INCOLOY alloy sheathed resistance type heater designed for no more than 95 watts per square inch. They shall be fastened through the top of the evaporating chamber. The two threaded ends of each heater element shall pass through the top of the evaporating chamber and be secured with threaded nuts to buss bars.

D. Thermal overload protection: A manual reset temperature switch shall be factory mounted and wired to ensure heater protection in the event of liquid level failure.

E. Heating Element Terminal Cover: A factory mounted and wired door interlock safety switch shall de-energize the heater when the cover is removed.

F. Inspection Plate/Sediment Tray: Provide easily removable tray to catch and hold minerals that are shed by the heaters and facilitate periodic clean-out.

G. Electronic Water Level Control: System shall provide for automatic refill, low water cut off and adjustable skimmer bleed-off functions. System shall consist off:
1. Water level sensing unit comprised of three metallic probes screwed into a threaded probe head, which shall incorporate probe isolation skirts to eliminate short circuiting between probes.
2. Solenoid operated fill valve factory mounted on the front of the humidifier.
3. VAPOR-LOGIC Microprocessor Control System.

H. Surface Skimmer/Overflow shall be provided which is electronically adjustable to provide for optimum mineral removal with minimum water waste.

I. Control Cabinet shall be UL listed enclosure. Control devices shall be mounted on a removable sub-panel within the enclosure. Control devices shall include VAPOR-LOGIC Microprocessor Control System, magnetic contactor for each heater, control circuit transformer, fuse set for each heating stage, numbered terminal strip an all interconnecting wiring. A wiring diagram is to be included and attached to the inside of the cabinet door. The cabinet shall be factory attached to side of humidifier and all wiring between cabinet and humidifier shall be completed at the factory.

J. VAPOR-LOGIC Microprocessor Control System shall have the following features:
1. LED fault indicator. Performs software self-diagnosis at every start-up.
2. Water make-up valve control and low water safety shutdown.
3. Auto drain/flush sequence whereby microprocessor accumulates actual 'on' time and activates auto drain/flush sequence.
4. End of season drain function when there has been no demand for humidification over a 72 hour period.
5. Four position functional slide switch on microprocessor board with stops at "AUTO", "STANDBY", "DRAIN", "TEST".
6. Electrical contactors shall be cycled equally.
7. The system shall modulate the humidifier output from 0% to 100%.
8. Keypad/Digital Display Module shall be housed in a thermoplastic enclosure, shipped loose for field mounting and shall provide the following features:
   a. Display shall continuously scroll all system functions including:
      1) Actual room RH
      2) Humidistat set point RH
      3) High limit humidistat setpoint
      4) Per heater demand %. Total system demand in % of total humidifier capacity, total system output lbs/hr.
      5) Time until service message
      6) High limit and air flow proving circuit condition
   b. Keypad shall enable the user to reset or adjust the following functions:

1) Humidistat RH setpoint
2) Humidistat RH high limit setpoint
3) Auto drain/flush frequency interval
4) Auto drain duration
5) Auto flush duration
6) PID loop
7) Throttling range
8) Time to go until next auto drain/flush sequence
9) Setting of cycle and delay times for proportional device
10) Electronic skim timer
11) Humidity and temperature transmitter trim adjustments

K. Factory insulation: Humidifier shall be covered with ¾" thick, rigid, foil faced fiberglass insulation. Insulation shall be covered with reinforced aluminum foil. All surfaces under the removable heater access panel shall be covered.

L. Dispersion Unit: Duct-mounting, manifold-grid tube extending across entire width of duct; connected to heat-exchanger housing with copper tubing and equipped with mounting brackets for both ends of tube. All tubes and headers shall be 304 stainless steel, and joints shall be Heliarc welded. Equal to Dristeem, Ultra-Sorb.

M. Provide a "Drane Kooler" drain tempering device: 304 stainless steel mixing chamber and fittings; brass tempering valve, drain valve, and vacuum breaker.

N. Optional Accessories and Options: Include the following:
1. Duct-mounted, high-limit humidistat.
2. Unit configured for hard piping to distribution unit.
3. Airflow switch to prevent humidifier operation when there is no airflow.
4. Modulating control.
5. Solid state relay control.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

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

3.2 HUMIDIFIER INSTALLATION

A. Install with required clearance for service and maintenance.

B. Install 1-1/2" copper steam supply piping from humidifier to the dispersion tube.

C. Seal humidifier dispersion-tube duct penetrations with flange.

D. Install dispersion tubes pitched to drain condensate back to housing.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to machine to allow service and maintenance.
2. Install shutoff valve and strainer in humidifier supply line.
3. Install backflow prevention device in humidifier supply line.

B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

C. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

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

3.5 DEMONSTRATION

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

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."

B. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

END OF SECTION 15752

SECTION 15815

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

A. This Section includes metal ducts for supply, return, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg (minus 500 to plus 2500 Pa). Metal ducts include the following:

1. Rectangular ducts and fittings.
2. Single-wall, round, spiral-seam ducts and formed fittings.

B. Related Sections include the following:

1. Division 7, Section 07270 "Through-Penetration Firestop Systems" for materials and methods for sealing duct penetrations through fire and smoke barriers.
2. Division 7, Section 07900 "Joint Sealants" for materials and methods for sealing duct penetrations through exterior walls.
3. Section 15816 "Nonmetal Ductwork" for fibrous-glass ducts.
4. Section 15820 "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.
5. Section 15071 "Mechanical Vibration and Seismic Controls".

1.3 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

B. NUSIG: National Uniform Seismic Installation Guidelines.

C. SMACNA – Sheet Metal and Air Conditioning Contractors' National Association, Inc. – latest edition.

1.4 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.5 SUBMITTALS

A. General: See Division 1 for general submittal and product substitution requirements.

B. Pre-construction Shop Drawings: Show fabrication and installation details for metal ducts as follows prior to commencing with fabrication and installation:

1. Metal gages.
2. Fittings.
3. Reinforcement and spacing.
4. Seam and joint construction.
5. Penetrations through fire-rated and other partitions.
6. Equipment installation based on equipment being used on Project.
7. Duct accessories, including access doors and panels.
8. Hangers and supports, including methods for duct and building attachment (Refer to Section 15071 for vibration isolation, and seismic restraints).

1.6 QUALITY ASSURANCE

A. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Transverse joints
   a. Ductmate Industries, Inc.
   b. Nexus Inc.
   c. Ward Industries, Inc.

2. Round and flat-oval duct and fittings
   a. McGill AirFlow Corporation.

b. SEMCO Incorporated.
c. Monroe Metal Mfg. Co.

3. Duct joints – round ducts
   a. Ductmate Industries, Inc.
   b. Lindab Inc

4. Duct joints – flat oval ducts
   a. Ductmate Industries, Inc.
   b. McGill AirFlow Corporation.
   c. SEMCO Incorporated

5. Flexible Metal Duct
   a. ATCO Rubber Products
   b. Anco Products Inc.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M, Type 304, and having a No. 2D finish for concealed ducts and No 4 for exposed ducts.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

2.3 SEALANT MATERIALS

A. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

B. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

C. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.

   1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
   2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
   3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.

2.5 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

   1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
   2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359 inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of nonbraced panel area unless ducts are lined.

2.6 ROUND DUCT AND FITTING FABRICATION

A. Manufacture in accordance with SMACNA HVAC Duct Construction Standards and as indicated. Provide duct material, gauges, reinforcement, and sealing for operating pressures indicated.

B. All duct and fittings shall be manufactured by a company whose primary business is the manufacture of spiral duct and fittings and who has been in business for at least 10 years. All spiral duct and fittings shall be manufactured by the same firm and shall be as shown on the contract drawings.

C. Round, Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

D. Duct Joints:

1. Ducts up to 20 Inches (500 mm) in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
2. Ducts 21 to 72 Inches (535 to 1830 mm) in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
3. Round Ducts: Prefabricated connection system consisting of two roll-formed galvanized steel mating flanges with an integral sealant, galvanized steel closure ring, and neoprene gasket. Manufacture ducts according to connection system manufacturer's tolerances.

E. Branch connections shall be made with 90 degree conical and 45 degree straight taps. All branch connections shall be made as separate fittings. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

F. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

G. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:

1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible.
2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg (minus 500 to plus 500 Pa):

   a. Ducts 3 to 36 Inches (75 to 915 mm) in Diameter: 0.034 inch (0.85 mm).
   b. Ducts 37 to 50 Inches (940 to 1270 mm) in Diameter: 0.040 inch (1.0 mm).
   c. Ducts 52 to 60 Inches (1320 to 1525 mm) in Diameter: 0.052 inch (1.3 mm).
   d. Ducts 62 to 84 Inches (1575 to 2130 mm) in Diameter: 0.064 inch (1.6 mm).

3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg (500 to 2500 Pa):

   a. Ducts 3 to 26 Inches (75 to 660 mm) in Diameter: 0.034 inch (0.85 mm).

b. Ducts 27 to 50 Inches (685 to 1270 mm) in Diameter: 0.040 inch (1.0 mm).
c. Ducts 52 to 60 Inches (1320 to 1525 mm) in Diameter: 0.052 inch (1.3 mm).
d. Ducts 62 to 84 Inches (1575 to 2130 mm) in Diameter: 0.064 inch (1.6 mm).

4. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
5. Round Elbows 12 Inches (200 mm) and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
6. Round Elbows 9 through 14 Inches (225 through 355 mm) in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
7. Round Elbows Larger Than 14 Inches (355 mm) in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
8. Die-Formed Elbows for Sizes through 12 Inches (200 mm) in Diameter and pressures through 10 inch wg: 24 gauge with 2-piece welded construction.
9. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
10. Pleated Elbows for Sizes through 14 Inches (355 mm) in Diameter and Pressures through 10-Inch wg (2500 Pa): 0.022 inch (0.55 mm).

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:

1. Supply Ducts (before Air Terminal Units): **6-inch wg.**
2. Supply Ducts (after Air Terminal Units): **1-inch wg .**
3. Return Ducts (Negative Pressure): 2-**inch wg .**
4. Exhaust Ducts (Negative Pressure): **1-inch wg.**

B. All ducts shall be galvanized steel except all supply and return ductwork serving the OR shall be stainless steel.

3.2 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. Install round ducts in lengths not less than 12 feet (3.7 m) unless interrupted by fittings.

C. Install ducts with fewest possible joints.

D. Install fabricated fittings for changes in directions, size, and shape and for connections.

E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches (300 mm), with a minimum of 3 screws in each coupling.

F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

G. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

H. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

I. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

J. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

K. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

L. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches (38 mm).

M. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 15 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 7 Section "Through-Penetration Firestop Systems."

N. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to Section 15071, "Mechanical Vibration and Seismic Controls".

O. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

3.3 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated, as required to meet requirements of the applicable energy code, and as outlined below.
   1. Supply Ducts – pressure classes equal to or lower than 2-inch wg:
      a. For ducts located in conditioned spaces: seal transverse joints.
      b. For ducts located in unconditioned spaces: seal all transverse joints and longitudinal seams.
      c. For ducts located outdoors: seal all transverse joints, longitudinal seams and duct wall penetrations.

2. Supply Ducts – pressure classes greater than 2-inch wg:
   a. For ducts located in conditioned spaces: seal all transverse joints and longitudinal seams.
   b. For ducts located in unconditioned spaces and outdoors: seal all transverse joints, longitudinal seams and duct wall penetrations.
3. Return Ducts, all pressure classes:
   a. For ducts located in conditioned spaces: seal transverse joints.
   b. For ducts located in unconditioned spaces: seal all transverse joints and longitudinal seams.
   c. For ducts located outdoors: seal all transverse joints, longitudinal seams and duct wall penetrations.
4. Exhaust ducts:
   a. For ducts located in conditioned spaces: seal all transverse joints and longitudinal seams.
   b. For ducts located in unconditioned spaces: seal all transverse joints only.

B. Seal ducts before external insulation is applied.

3.4 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches (600 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet (5 m) and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

3.5 CONNECTIONS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

A. Ductwork constructed to greater than 3" w.g. class shall be leak tested.

B. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:

1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.

3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round and flat-oval ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch wg (500 Pa) (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2- to 10-inch wg (500 to 2500 Pa). In no case shall duct leakage exceed amounts specified in the applicable energy code.
4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

3.7 CLEANING NEW SYSTEMS (Serving OR)

A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

B. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Create other openings to comply with duct standards.
2. Disconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling sections to gain access during the cleaning process.

C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply fan including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including coil section, condensate drain pans, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Humidifiers.
6. Supply-air ducts, dampers, actuators, and turning vanes.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
5. After the system is balanced and before the system is placed into operation, all components of the system downstream of the HEPA filter, including ductwork and accessories, must be decontaminated by wiping with germicidal solution.

F. Cleanliness Verification:

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and re-inspect ducts.

END OF SECTION

SECTION 15820

DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

A. This Section includes the following:
1. Volume dampers.
2. Smoke dampers.
3. Turning vanes.
4. Duct-mounting access doors.
5. Flexible connectors.
6. Flexible ducts.
7. Duct accessory hardware.

B. Related Sections include the following:

1. Division 13, Section 13851 "Fire Alarm" for duct-mounting fire and smoke detectors.
2. Division 15, Section 15900 "HVAC Instrumentation and Controls" for electric and pneumatic damper actuators.

1.3 SUBMITTALS

A. Product Data: For the following:
1. Volume dampers.
2. Smoke dampers.
3. Turning vanes.
4. Duct-mounting access doors.
5. Flexible connectors.
6. Flexible ducts.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Special fittings.
2. Manual-volume damper installations.
3. Smoke-damper installations, including sleeves and duct-mounting access doors.
4. Wiring Diagrams: Power, signal, and control wiring.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Volume dampers
   a. Air Balance, Inc.
   b. American Warming and Ventilating.
   c. Flexmaster U.S.A., Inc.
   d. McGill AirFlow Corporation.
   e. METALAIRE, Inc.
   f. Nailor Industries Inc.
   g. Penn Ventilation Company, Inc.
   h. Ruskin Company.
   i. Vent Products Company, Inc.

2. Smoke dampers
   a. Air Balance, Inc.
   b. CESCO Products.
   c. Greenheck.
   d. Nailor Industries Inc.
   e. Penn Ventilation Company, Inc.
   f. Ruskin Company.

3. Manufactured turning vanes
   a. Ductmate Industries, Inc.
   b. Duro Dyne Corp.
   c. METALAIRE, Inc.

d. Ward Industries, Inc.

4. Duct-mounting access doors – rectangular
   a. American Warming and Ventilating.
   b. CESCO Products.
   c. Ductmate Industries, Inc.
   d. Flexmaster U.S.A., Inc.
   e. Greenheck.
   f. McGill AirFlow Corporation.
   g. Nailor Industries Inc.
   h. Ventfabrics, Inc.
   i. Ward Industries, Inc.

5. Flexible ducts
   a. Flexmaster U.S.A., Inc.
   b. Hart & Cooley, Inc.
   c. McGill AirFlow Corporation.
   d. ATCO Rubber Products, Inc.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 (Z275) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M.

D. Aluminum Sheets: ASTM B 209 (ASTM B 209M), alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: ASTM B 221 (ASTM B 221M), alloy 6063, temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

2.3 VOLUME DAMPERS

A. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

1. Pressure Classes of 3-Inch wg (750 Pa) or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

B. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, and suitable for horizontal or vertical applications.

1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch (1.62 mm) thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2. Roll-Formed Steel Blades: 0.064-inch- (1.62-mm-) thick, galvanized sheet steel.
3. Aluminum Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
4. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
5. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
6. Blade Axles: Galvanized steel.
7. Bearings: Oil-impregnated bronze or Molded synthetic.
8. Tie Bars and Brackets: Aluminum.
9. Tie Bars and Brackets: Galvanized steel.

C. Jackshaft: 1-inch- (25-mm-) diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.4 SMOKE DAMPERS

A. General Description: Tested and labeled according to UL 555S, leakage class 1, equal to Ruskin Model SD60.

B. Frame and Blades: 0.064-inch- (1.62-mm-) thick, galvanized sheet steel.

C. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.

D. Damper Motors: Modulating and two-position action.

1. Comply with requirements in Division 15 Section "Motors."
2. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
3. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).

4. Outdoor Motors and Motors in Outside-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
5. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
6. Electrical Connection: 115 V, single phase, 60 Hz.

2.5 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- (38-mm-) wide, single, curved blades of galvanized sheet steel set 3/4 inch (19 mm) o.c.; support with bars perpendicular to blades set 2 inches (50 mm) o.c.; and set into vane runners suitable for duct mounting.

C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.6 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.

1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
2. Provide number of hinges and locks as follows:

    a. Less Than 12 Inches (300 mm) Square: Secure with two sash locks.
    b. Up to 18 Inches (450 mm) Square: Two hinges and two sash locks.
    c. Up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches[**with outside and inside handles**].
    d. Sizes 24 by 48 Inches (600 by 1200 mm) and Larger: One additional hinge.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch (25-mm) thickness. Include cam latches.

1. Frame: Galvanized sheet steel, with spin-in notched frame.

D. Pressure Relief Access Door: [**Single**] [**Double**] wall and duct mounting; fabricated of galvanized sheet metal[**with insulation fill and thickness**] as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain.

1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

F. Insulation: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.7 FLEXIBLE CONNECTORS

A. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

B. Metal-Edged Connectors: Factory fabricated with a fabric strip **[3-1/2 inches (89 mm)]** **[5-3/4 inches (146 mm)]** wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Select metal compatible with ducts.

C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

2.8 FLEXIBLE DUCTS

A. Noninsulated-Duct Connectors: UL 181, Class 0, all metal duct of heavy gauge corrugated aluminum with watertight continuous lock seams.

1. Pressure Rating: 8-inch wg (2280 Pa) positive or negative.
2. Maximum Air Velocity: 5000 fpm (25.4 m/s).
3. Temperature Range: Minus 100 to plus 435 deg F (Minus 73 to plus 224 deg C).

B. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor barrier film.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20.3 m/s).
3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).

C. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches (75 to 450 mm) to suit duct size.

2.9 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

D. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

E. Provide test holes at fan inlets and outlets and elsewhere as indicated.

F. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

1. At duct coils.
2. Adjacent to smoke dampers.
3. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot (15-m) spacing.
4. On sides of ducts where adequate clearance is available.

G. Install the following sizes for duct-mounting, rectangular access doors:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).

H. Install the following sizes for duct-mounting, round access doors:

1. One-Hand or Inspection Access: 8 inches (200 mm) in diameter.
2. Two-Hand Access: 10 inches (250 mm) in diameter.
3. Head and Hand Access: 12 inches (300 mm) in diameter.
4. Head and Shoulders Access: 18 inches (460 mm) in diameter.

I. Label access doors according to Division 15 Section "Mechanical Identification."

J. For fans developing static pressures of 5-inch wg (1250 Pa) and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

K. Connect diffusers to low pressure ducts directly or with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.

L. All flexible ducts serving the Operating Room shall be aluminum construction.

M. Connect flexible ducts to metal ducts with draw bands.

N. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 15, Section 15950 "Testing, Adjusting, and Balancing."

END OF SECTION

SECTION 15840

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Shutoff single-duct air terminal units.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. Certified Sound Data: Terminal unit manufacturer shall furnish certified sound data for both casing and discharge and radiated sound levels as tested in an ADC certified laboratory in strict accordance with ADC test Standard 1062 R4. Sound levels shall not exceed those indicated on the terminal unit schedule.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.

   1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
   2. Wiring Diagrams: Power, signal, and control wiring.

D. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Closeout Procedures," include the following:

   1. Instructions for resetting minimum and maximum air volumes.
   2. Instructions for adjusting software set points.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

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

C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.5 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Single-Duct Air Terminal Units
   a. Enviro-Tec.
   b. Metal*Aire.
   c. Titus.

2.2 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

A. Basis of Design: Enviro-Tec SDR.

B. Terminal boxes shall be pressure independent and not be less than 6 inches in diameter.

C. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

D. Casing: 22 gauge galvanized steel.
   1. Foil Faced Casing Lining: Hospital grade, fiberglass insulation with scrim backed foil facing, adhesive attached, 1 inch thick, non-porous insulation with sealed edges complying with NFPA 90A, UL 181 erosion requirements, and having a maximum

flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

2. Air Inlet: Round stub connection for duct attachment.
3. Air Outlet: S-slip and drive connection.
4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.

E. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with Delrin-fitted pivot points located inside unit casing.

1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
2. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

F. Primary Airflow Sensor:

1. Differential pressure airflow sensor shall traverse the duct using the equal cross sectional area or log-linear traverse method along two perpendicular dimensions. Single axis sensor shall not be acceptable. A minimum of 12 total pressure sensing points shall be utilized. Brass balancing taps and airflow calibration charts shall be provided for field airflow measurements.

G. Volume Damper: Galvanized steel, minimum 22 gauge, with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 1 percent of nominal airflow when tested in accordance with ADC Test Procedure 1062 R4.

H. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 300 psig; and factory installed.

I. DDC Controls:

1. Units shall incorporate Honeywell DDC Controls. DDC controls and motor shall be furnished by the control contractor and installed by the terminal unit manufacturer.

2. Unitary controller and actuator specified in Division 15 Section "HVAC Instrumentation and Controls."

3. Communication with temperature-control system specified in Division 15 Section "HVAC Instrumentation and Controls."

4. DDC Zone Sensor: Refer to Section 15900 "HVAC Instrumentation and Controls".

J. Sound Levels: Manufacturer shall furnish certified sound data for both casing discharge and radiated sound levels as tested in an ADC certified laboratory in stict accordance with ADC test Standard 1062 R4 and shall include second through seventh octave band data for all unit sizes. Both discharge and radiated NC levels shall be based on a 10 db sound absorption as

determined by subtraction from the highest point on the power level curve. Sound level shall not exceed those indicated on the schedule.

2.3 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with Tag as Scheduled on the Drawings, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

B. Verification of Performance: Rate air terminal units according to ARI 880.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

B. Hot water coils shall be insulated in the field.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air terminal units to allow service and maintenance.

C. Hot-Water Piping: In addition to requirements in Section 15181 "Hydronic Piping and Specialties", connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union as detailed on the Drawings.

D. Connect ducts to air terminal units as detailed on the Drawings and according to Section 15815 "Metal Ducts."

E. Connect wiring and ground equipment in accordance with Division 16.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.

2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.4 STARTUP SERVICE

A. Complete installation and startup checks according to manufacturer's written instructions and do the following:
1. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
2. Verify that controls and control enclosure are accessible.
3. Verify that control connections are complete.
4. Verify that nameplate and identification tag are visible.
5. Verify that controls respond to inputs as specified.

END OF SECTION 15840

SECTION 15855

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

B. Related Sections include the following:

1. Division 10, Section 10200 "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 15, Section 15820 "Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. General: See Division 1 for general submittal and product substitution requirements.

B. Pre-construction Shop Drawings: Show fabrication and installation details for metal ducts as follows prior to commencing with fabrication and installation:
1. Product Data: For each product indicated, include the following:
   a. Data Sheet: Indicate materials of construction, finish, color, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   b. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

a. METALAIRE, Inc.; Metal Industries Inc.
b. Nailor Industries of Texas Inc.
c. Titus.
d. Tuttle & Bailey.

2.2 LOUVERD FACED CEILING DIFFUSERS.

A. Basis of Design: Metalair Series 5000.
1. Type: Louvered face, ceiling mount, round neck, fixed airflow pattern.
2. Construction: Aluminum, with square inlet and square to round inlet transition piece. The inner louver assembly shall be flush with outer frame with a 1, 2, 3, or 4-way as scheduled. The inner core assembly shall be removable in the field without the use of tools.
3. Finish: White, electrocoated anodic acrylic paint, baked at 315 deg F for 30 minutes with a pencil hardness of HB to H.
4. Frame: Lay-in T-Bar type as scheduled.
5. Damper: Opposed-blade type, operable from the face of the diffuser. Provide only where remote branch damper is not possible.
6. Accessories: As scheduled.
7. Sizes and performance: As scheduled.

2.3 LOUVERED RETURN/EXHAUST GRILLES AND REGISTERS

A. Basis of Design: Metalaire, Model H4002R
1. Fabrication: Aluminum with factory white baked enamel finish.
2. Damper: Provide where remote branch damper is not possible. Integral, gang-operated, opposed blade type with removable key operator, operable from face.
3. Provide panel for lay-in installation as scheduled.
4. Accessories: As Scheduled.
5. Sizes and Performance: As scheduled.

2.4 STAINLESS STEEL LOUVERED EXHAUST GRILLE SERVING OR.

A. Basis of Design: Titus 350 SS
a. Fabrication: Type 304 stainless steel.
b. Surface mounted.
c. Blades: ¾ inch spacing, 45 degree fixed deflection.
d Sizes and performance: As scheduled.

2.5 OPERATING ROOM AIR DISTRIBUTION SYSTEM

A. Basis of Design: Metalaire, Periflow System
   1. System shall consist of non-aspirating, laminar flow center panels providing air supply over the operating table and multiple slot panels providing an air curtain flow around the operating table.
   2. All components of the system shall be fabricated of stainless steel. Factory supplied plenums shall be constructed of a minimum of 20-gauge Type 304 stainless steel with a ¾ inch radius for ease of sterilization.
   3. Stainless steel perforated plate shall be permanently attached to both the center and perimeter panels to provide equal air distribution over the diffuser face.
   4. Face of panels shall be retained by quarter turn fasteners and shall have safety cables to retain face of panel upon release of fastener.
   5. Laminar flow panels:
      a. 20 gauge, type 304 stainless steel, #4 exterior finish, #2 interior finish.
      b. Single inlet connection.
   6. Perimeter panels:
      a. 18 gauge, type 304 stainless steel, #4 exterior finish, #2 interior finish.
      b. Laminar flow pattern, projecting air outward between 5-degree and 15-degree angle.
      c. Panels shall have plenum system configures as shown on the drawings.

2.6 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling

panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, and fire dampers.

D. Operating Room Air Distribution System: After the system is balanced and before the system is placed into operation, all components of the system downstream of the HEPA filter, including ductwork and accessories, must be decontaminated by wiping with germicidal solution. Follow manufacturer's recommended procedures for decontaminating supply panels.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 15900

HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:
1. Division 13, Section 13851 "Fire Alarm" for fire and smoke detectors mounted in HVAC systems and equipment.
2. Division 15, Section 15942 "Sequence of Operation - Educational" for requirements that relate to this Section.
3. Division 16, Section 16215 "Electrical Power Monitoring and Control."

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

B. LAN: Local area network.

C. MS/TP: Master-slave/token-passing.

D. PICS: Protocol Implementation Conformance Statement.

1.4 SYSTEM DESCRIPTION

A. The control system shall be an extension of the existing Honeywell control system.

B. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers

operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems.

C. Controls for variable air volume terminal units shall be 24 volt and shall be wired by Division 15.

1.5 SUBMITTALS

A. General: See Division 1 for general submittal and product substitution requirements.

B. Pre-Construction Submittals: Submit the following items prior to commencing with installations.
   1. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
      a. Each control device labeled with setting or adjustable range of control.
   2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
      1) Schematic flow diagrams showing fans, coils, dampers, valves, and control devices.
      b. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
      c. Details of control panel faces, including controls, instruments, and labeling.
      d. Schedule of dampers including size, leakage, and flow characteristics.
      e. Schedule of valves including leakage and flow characteristics.
      f. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
      g. Listing of connected data points, including connected control unit and input device.
      h. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
      i. System configuration showing peripheral devices, batteries, power supplies, diagrams, and interconnections.
   3. Software and Firmware Operational Documentation: Include the following:
      a. Software operating and upgrade manuals.
      b. Device address list.

C. Post Construction Submittals: Submit the following items upon completion of system installations.
   1. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
   2. Maintenance Data: For systems to include in maintenance manuals specified in Division 1. Include the following:
      a. Maintenance instructions and lists of spare parts for each type of control device.
      b. Interconnection wiring diagrams with identified and numbered system components and devices.

c. Keyboard illustrations and step-by-step procedures indexed for each operator function.
d. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
e. Calibration records and list of set points.

D. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

E. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative or a certified installer of the automatic control system manufacturer for both installation and maintenance of units required for this Project.

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

C. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

D. Comply with ASHRAE 135 for DDC system control components.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

1.8 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 13 Section "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate supply of conditioned electrical circuits for control units.

D. Coordinate equipment with Division 16 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

1. The extension of the DDC system shall be Honeywell Controls.
2. Operating Room pressure controls: TSI Inc. or approved equal.

2.2 DDC EQUIPMENT

A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each input/output point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator station.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

    a. Global communications.
    b. Discrete/digital, analog, and pulse input/output.
    c. Monitoring, controlling, or addressing data points.
    d. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Local operator interface provides for download from or upload to mobile operator station.

B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each input/output point; process information; and download from or upload to operator station.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

    a. Global communications.
    b. Discrete/digital, analog, and pulse input/output.
    c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to mobile operator station.

2.3 Software: Exiting with modifications as necessary to achieve sequence of operation.

2.4 CONTROL PANELS

A. Local Control Panels: Unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.

1. Fabricate panels of 0.06-inch- (1.5-mm-) thick, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.
2. Panel-Mounted Equipment: Temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.
3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.
4. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.

2.5 ANALOG CONTROLLERS

A. Step Controllers: Six- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

C. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.

1. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig (21 to 90 kPa).
2. Proportional band shall extend from 2 to 20 percent for 5 psig (34 kPa).
3. Authority shall be 20 to 200 percent.

2.6 SENSORS

A. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

1. Humidity Sensors: Bulk polymer sensor element.

a. Accuracy: 2 percent full range with linear output.
b. Room Sensors: With cover matching room thermostats, span of 20 to 90 percent relative humidity.
c. Setpoint adjustment.
d. Digital humidity display.

B. Equipment operation sensors as follows:

1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg (0 to 1243 Pa).

C. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

2.7 ROOM THERMOSTATS

A. Electric solid-state, microcomputer-based room thermostat with remote sensor.

1. Automatic switching from heating to cooling.

2. Temperature Range: 55 degrees F to 95 degrees F.

3. Setpoint adjustement.

4. Digital temperature display.

2.8 HUMIDISTATS

A. Duct-Mounted Humidistats: Electric insertion, 2-position type with adjustable 2 percent throttling range, 20 to 80 percent operating range, single- or double-pole contacts.

2.9 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Division 15 Section "Motors."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
4. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).

5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).

B. Electronic damper and large valve Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Valves: Size for torque required for valve close-off at maximum pump differential pressure.
2. Dampers: Size for running torque calculated as follows:
   a. Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. (62 kg-cm/sq. m) of damper.

3. Coupling: V-bolt and V-shaped, toothed cradle.
4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.

2.10 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

B. Globe Valves NPS 2 (DN 50) and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.

C. Terminal Unit Control Valves: Bronze body, bronze trim, two- or three-port as indicated, replaceable plugs and seats, union and threaded ends.

1. Rating: Class 125 for service at 125 psig (862 kPa) and 250 deg F (121 deg C) operating conditions.
2. Sizing: 3-psig (21-kPa) maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

2.11 DAMPERS

A. Dampers: AMCA-rated, opposed-blade design; 0.1084-inch (2.8-mm) minimum, galvanized-steel frames with holes for duct mounting; damper blades shall not be less than 0.0635-inch (1.6-mm) galvanized steel with maximum blade width of 8 inches (203 mm).

1. Blades shall be secured to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).

3. For standard applications, include optional closed-cell neoprene edging.
4. For low-leakage applications, use parallel- or opposed-blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. (51 L/s per sq. m) of damper area, at differential pressure of 4 inches wg (995 Pa) when damper is being held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

2.12 OPERATING ROOM PRESSURE CONTROLS

A. Basis of Design: TSI Inc. SureFlow Model 8630-PC-CR Room Pressure Controller with Model 8694-7 key switch

B. Completely designed, tested, cataloged, and factory coordinated package from a single manufacturer.

C. The room pressure control system shall measure the room pressure differential (+0.01 in. wg.). The room pressure control system shall accept one flow measurement. The flow measurement shall be a 1-10V signal, linear with respect to either velocity pressure or velocity.

D. The pressure controller shall have a digital display of all configuration parameters. Configuration shall be done through a keypad integral to the controller. Password protection shall limit unauthorized access to configuration parameters. The controller shall also have indicator lights for low and high alarm and normal operating conditions. An analog output of room pressure differential shall be user-configurable to either 0-10V or 4-20mA. The room pressure controller shall have an RS-485 communications port, supporting the MODBUS protocol for seamless integration to the building automation system.

E. The controller shall have a control relay tied to the ROOM MODE of the controller used to signal the DDC system as to the Pressurized/Neutral mode status. The controller shall have software allowing the testing of the control relay.

F. The room pressure sensor shall be bi-directional. The sensor shall be capable of being mounted in the corridor or the Operating Room. The room pressure sensor shall use two in-line ceramic coated RTD's to measure the pressure differential. The room pressure sensor shall be temperature compensated over a range of 55 degrees F to 95 degrees F. Field-calibration of the sensor shall be performed through the keypad on the room pressure controller.

G. The key switch shall be used to change the mode from pressurized mode to neutral mode and shall include a visual alarm.

H. Performance Requirements:
1. The room pressure sensor shall have a resolution of 5% of the measured value and shall detect any change in the room pressure within 0.1 second, with a minimum reading of 0.0001 in. wg.
2. The room pressure control system shall control the central system return air motorized damper with a 0-10 VDC signal to maintain room pressurization.
3. The room pressure control system shall have a PID control algorithm with two sets of tuning constants. The room pressure control system shall update the control output 10 times per second.

4. Local audible and visual alarms shall be enabled whenever measured room pressure differential falls below its user configurable low alarm set point or rises above its user configurable high alarm point. Relay contacts shall be enabled on a low alarm. All alarms shall be enabled after a configurable delay. A mute key shall temporarily silence the audible alarm for a user configurable delay. Manual or automatic reset of the alarms shall be configurable.
5. The room pressure control system shall accept an input from a keyswitch. The keyswitch shall change the room mode from positive to neutral. In the neutral mode, the room pressure controller will disable all alarms.
6. Calibration of room pressure differential shall be done electronically through the use of the integral keypad. Calibration shall consist of adjusting the sensor zero point and sensor span to match a reference measurement. Password protection of the calibration items shall limit access.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units.

B. Verify that duct-, pipe-, and equipment-mounted devices and wiring are installed before proceeding with installation.

3.2 INSTALLATION

A. Install equipment level and plumb.

B. Install software in control units. Implement all features of programs to specified requirements and as appropriate to sequence of operation.

C. Connect and configure equipment and software to achieve sequence of operation specified.

D. Verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Locate all 60 inches (1524 mm) above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

E. Install automatic dampers according to Division 15 Section "Duct Accessories."

F. Install labels and nameplates to identify control components according to Division 15 Section "Basic Mechanical Materials and Methods."

G. Install labels and nameplates to identify control components according to Division 15 Section "Mechanical Identification."

H. Install hydronic instrument wells, valves, and other accessories according to Division 15 Section "Hydronic Piping."

I. Install duct volume-control dampers according to Division 15 Sections specifying air ducts.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 16 Section "Raceways and Boxes."

B. Install building wire and cable according to Division 16 Section "Conductors and Cables."

C. Install signal and communication cable according to Division 16 Section "Control/Signal Transmission Media."

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway.
3. Install concealed cable in raceway.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

3.4 CONNECTIONS

A. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including electrical connections. Report results in writing.
1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
3. Calibration test electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

B. Engage a factory-authorized service representative to perform startup service.

C. Replace damaged or malfunctioning controls and equipment.

1. Start, test, and adjust control systems.

2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

D. Verify DDC as follows:

1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.
2. Verify local control units including self-diagnostics.

3.6 DEMONSTRATION

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

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs.
3. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."
4. Schedule training with Owner with at least seven days' advance notice.

3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

END OF SECTION

SECTION 15940

SEQUENCE OF OPERATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

B. Related Sections include the following:

1. Division 15, Section 15900 "HVAC Instrumentation and Controls" for control equipment and devices and submittal requirements.

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

B. VAV: Variable air volume.

PART 2 - PRODUCTS (not used)

PART 3 - EXECUTION

3.1 OPERATING ROOM VAV TERMINAL UNIT (VAV-1)

A. VAV terminal unit shall modulate to maintain constant airflow as scheduled.

3.2 VAV TERMINAL UNITS WITH REHEAT COILS:

A. Sensor set at 72 deg. F (adjustable) shall maintain constant zone temperature by modulating variable volume damper operator. On a rise in temperature above the cooling setpoint, the VAV terminal unit shall modulate to its maximum CFM. As the zone temperature drops below the cooling setpoint, the terminal unit shall modulate to its minimum CFM. As the zone temperature continues to fall, the proportional two-way hot water reheat coil control valve shall modulate open.

3.3 OPERATING ROOM

A. A wall mounted Occupied/Unoccupied switch shall signal DDC system as to operational status.

B. In 'Occupied' mode, the DDC system shall signal the variable frequency drive serving air handling unit AHU-1 to maintain full flow as scheduled. The variable air volume terminal unit, VAV-1, shall supply constant amount of central system air as scheduled.

C. In 'Unoccupied' mode, the DDC system shall signal the variable frequency drive to maintain minimum airflow as scheduled. The variable air volume terminal unit, VAV-1, shall supply constant amount of central system air as scheduled.

D. The air handling unit chilled water valve and hot water valve shall modulate in sequence to maintain the space temperature setpoint.

E. The DDC system shall control room humidity to maintain the room adjustable set point as follows:
   a. Whenever the room humidity falls below setpoint, an analog signal shall be sent to the humidifier control system enabling the humidifier to operate under its factory supplied controls (See Section 15752).
   b. Whenever the room humidity rises above the setpoint, the air handler's chilled water valve shall modulate open to provide dehumidification and the hot water control valve shall modulate to maintain room temperature setpoint.

F. A fan pressure switch shall send an alarm to the DDC system upon loss of airflow from AHU-1.

G. Room pressure shall be controlled by the Room Pressure Controller as specified under Section 15900 and shall communicate the room status (positive/neutral) to the DDC system. Provide alarm.

END OF SECTION

SECTION 15950

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The requirements of Section 15000, "Basic Mechanical Requirements" apply to work defined by this Section.

C. The requirements of Section 15050, "Basic Mechanical Materials and Methods" apply to work defined by the Section.

1.2 SUMMARY

A. This Section includes TAB to produce design objectives for the following:

1. Air Systems:
   a. Variable-air-volume systems.

2. Hydronic Piping Systems:
   a. Variable-flow systems.

3. HVAC equipment quantitative-performance settings.
4. Space pressurization testing and adjusting.
5. Existing systems TAB.
6. Verifying that automatic control devices are functioning properly.
7. Reporting results of activities and procedures specified in this Section.

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.

I. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

J. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

K. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

L. TAB: Testing, adjusting, and balancing.

M. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

N. Test: A procedure to determine quantitative performance of systems or equipment.

O. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 SUBMITTALS

A. Contract Documents Examination Report: Submit 2 copies of the Contract Documents review report as specified in Part 3.

B. Strategies and Procedures Plan: Submit 2 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

C. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

D. Sample Report Forms: Submit two sets of sample TAB report forms.

E. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.

B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

D. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

E. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 1 Section "Project Record Documents."

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine strainers for clean screens and proper perforations.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine equipment for installation and for properly operating safety interlocks and controls.

O. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices are operated by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at indicated values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems".

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

D. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

E. Check dampers for proper position to achieve desired airflow path.

F. Check for airflow blockages.

G. Check condensate drains for proper connections and functioning.

H. Check for proper sealing of air-handling unit components.

I. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR VARIABLE-VOLUME AIR SYSTEM SERVING OPERATING ROOM

A. Adjust fan to deliver total indicated maximum and minimum airflows within the allowable fan speeds listed by fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.

b. Measure static pressure directly at the fan outlet or through the flexible connection.
c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.

2. Measure static pressure across each component that makes up an air-handling unit.

a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps under final balanced conditions.
4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur.

B. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

C. Adjust terminal outlets and inlets to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEEDURE FOR VARIABLE AIR VOLUME TERINAL UNITS

1. Adjust inlet dampers of each terminal unit to full indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
2. Adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.

a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

3.7 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.8 PROCEDURES FOR HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

3.9 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.10 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS

A. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

B. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.

1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
2. Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test overpressurization and underpressurization, and observe and report on the system's ability to revert to the set point.

C. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

D. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.11 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the airflow.
2. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Air balance each air outlet.

3.12 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

J. Note operation of electric actuators using spring return for proper fail-safe operations.

3.13 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Equipment with Fans: Plus 5 to plus 10 percent.
2. Air Outlets and Inlets: 0 to minus 10 percent.
3. Heating-Water Flow Rate: 0 to minus 10 percent.
4. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.14 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.15 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:
1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB firm who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Fan drive settings including settings and percentage of maximum pitch diameter.
    e. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.

f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches (mm), and bore.
i. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
j. Number of belts, make, and size.
k. Number of filters, type, and size.

2. Motor Data:

a. Make and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Filter static-pressure differential in inches wg (Pa).
f. Cooling coil static-pressure differential in inches wg (Pa).
g. Heating coil static-pressure differential in inches wg (Pa).
h. Return airflow in cfm (L/s).

G. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch (mm) o.c.
f. Make and model number.
g. Face area in sq. ft. (sq. m).
h. Tube size in NPS (DN).
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).
b. Average face velocity in fpm (m/s).
c. Air pressure drop in inches wg (Pa).
d. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
e. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
f. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).

g. Water flow rate in gpm (L/s).
h. Water pressure differential in feet of head or psig (kPa).
i. Entering-water temperature in deg F (deg C).
j. Leaving-water temperature in deg F (deg C).
k. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup

H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling unit number.
b. Location and zone.
c. Traverse air temperature in deg F (deg C).
d. Duct static pressure in inches wg (Pa).
e. Duct size in inches (mm).
f. Duct area in sq. ft. (sq. m).
g. Indicated airflow rate in cfm (L/s).
h. Indicated velocity in fpm (m/s).
i. Actual airflow rate in cfm (L/s).
j. Actual average velocity in fpm (m/s).
k. Barometric pressure in psig (Pa).

I. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Test apparatus used.
d. Area served.
e. Air-terminal-device make.
f. Air-terminal-device number from system diagram.
g. Air-terminal-device type and model number.
h. Air-terminal-device size.
i. Air-terminal-device effective area in sq. ft. (sq. m).

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).
b. Air velocity in fpm (m/s).
c. Preliminary airflow rate as needed in cfm (L/s).
d. Preliminary velocity as needed in fpm (m/s).
e. Final airflow rate in cfm (L/s).
f. Final velocity in fpm (m/s).
g. Space temperature in deg F (deg C).

J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

    a. System and air-handling unit identification.
    b. Location and zone.
    c. Room or riser served.
    d. Coil make and size.
    e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

    a. Airflow rate in cfm (L/s).
    b. Entering-water temperature in deg F (deg C).
    c. Leaving-water temperature in deg F (deg C).
    d. Water pressure drop in feet of head or psig (kPa).
    e. Entering-air temperature in deg F (deg C).
    f. Leaving-air temperature in deg F (deg C).

K. Instrument Calibration Reports:

1. Report Data:

    a. Instrument type and make.
    b. Serial number.
    c. Application.
    d. Dates of use.
    e. Dates of calibration.

3.16 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
2. Randomly check the following for each system:

    a. Measure airflow of at least 10 percent of air outlets.
    b. Measure water flow of at least 5 percent of terminals.
    c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
    d. Measure space pressure of at least 10 percent of locations.
    e. Verify that balancing devices are marked with final balance position.
    f. Note deviations to the Contract Documents in the Final Report.

END OF SECTION