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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2009

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SECTION 23 36 00

AIR TERMINAL UNITS

08/08

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**NOTE:** This specification covers the requirements for bypass single-duct air terminal units, dual-duct air terminal units, fan-powered air terminal units, induction air terminal units, shutoff single-duct air terminal units and integral-diffuser air terminal units for air handling systems.

Drawings and schedules must portray system dynamics so that equipment functions as required.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

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PART 1 GENERAL

1.1 REFERENCES

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**NOTE:** This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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

AIR DIFFUSION COUNCIL (ADC)

ADC Standards Manual (2002-2007) Flexible Duct Performance and Installation Standards

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 880 (2008) Standard for Air Terminals

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 130 (2008) Method of Testing for Rating Ducted Air Terminal Units

ASTM INTERNATIONAL (ASTM)

ASTM A 653/A 653M (2008) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM C 1071 (2005e1) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

ASTM E 84 (2009) Standard Test Method for Surface Burning Characteristics of Building Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2008) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2007; AMD 1 2008) National Electrical Code - 2008 Edition

NFPA 90A (2008) Standard for the Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 181 (2005; Rev thru Oct 2008) Standard for  
Factory-Made Air Ducts and Air Connectors

UL 486A-486B (2003; Rev thru Apr 2009) Standard for  
Wire Connectors

1.2 SUBMITTALS

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**NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.**

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

**SD-01 Preconstruction Submittals**

**Records of Existing Conditions** must be submitted in accordance with paragraph entitled, "General Requirements," of this section.

**SD-02 Shop Drawings**

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

- Bypass Single-Duct Air Terminal Units
- Dual-Duct Air Terminal Units
- Fan-Powered Air Terminal Units
- Induction Air Terminal Units
- Shutoff Single-Duct Air Terminal Units
- Integral-Diffuser Air Terminal Units
- High-Pressure Dual-Duct Mixing Boxes
- Low-Pressure Dual-Duct Mixing Boxes

Include a schedule showing unique model designation, room location, model number, size, and accessories furnished. Include wiring diagrams to show power, signal, and control wiring.

Record Drawings and Spare Parts must be submitted in accordance with paragraph entitled, "General Requirements," of this section.

SD-03 Product Data

For each type of air terminal units indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories

- Bypass Single-Duct Air Terminal Units
- Dual-Duct Air Terminal Units
- Fan-Powered Air Terminal Units
- Induction Air Terminal Units
- Shutoff Single-Duct Air Terminal Units
- Integral-Diffuser Air Terminal Units
- High-Pressure Dual-Duct Mixing Boxes
- Low-Pressure Dual-Duct Mixing Boxes

SD-10 Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with paragraph entitled, "Operation and Maintenance," of this section.

1.3 GENERAL REQUIREMENTS

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**NOTE: If Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.**  
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Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS applies to work specified in this section.

Materials, Equipment, and Fixture Lists must be submitted for all materials, equipment, and fixtures to be incorporated in the work. Lists must include manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

Records of Existing Conditions must be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work must constitute acceptance of existing conditions.

Record Drawings must be submitted providing current factual information, including deviations and amendments to the drawings, and concealed and visible changes in the work.

Units must be provided with the configuration, capacity, and static-pressure characteristics indicated.

Where dimensional data are given, these must constitute nominal sizing, which must be adjusted by the manufacturer when necessary to accommodate acoustic material thickness.

Units identical to the proposed units must have at least 2 years of proven satisfactory field service.

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**NOTE: Select or delete the following paragraph  
after checking current "Directory of Air Diffusion  
Council (ADC Standards Manual) Certified Products."**  
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Units and spare parts must be certified as having been ADC Standards Manual tested and rated.

#### 1.4 QUALITY ASSURANCE

Indicate drawings size, profiles, and dimensional requirements of air terminal units which are based on the specific system indicated.

Conform to NFPA 70, Article 100 for electrical components, devices, and accessories: List and label as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

Air Terminals must be certified under the AHRI 880 Certification Program and must carry the ARI Seal.

Install air terminals units according to NFPA 90A.

#### 1.5 COORDINATION

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 BYPASS SINGLE-DUCT AIR TERMINAL UNITS

##### 2.1.1 Configuration

Provide diverting-damper assembly inside unit casing with control components located inside a protective metal shroud.

### 2.1.2 Casing

Provide 0.85 mm 0.034 inch steel casing. Provide 13 mm 1/2 inch thick, coated, fibrous-glass duct casing lining complying with ASTM C 1071. Secure with adhesive. For the air inlet provide round stub connection for duct attachment. For the air outlet provide s-slip and drive connections. For access provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket.

### 2.1.3 Diverter Assembly

Provide [galvanized-steel gate, with polyethylene linear bearings] [aluminum blade, with nylon-fitted pivot points] [\_\_\_\_\_] diverter assembly.

### 2.1.4 Multi-Outlet Attenuator Section

Provide [two][ three][ four][ \_\_\_\_\_] [150 mm 6 inch][200 mm 8 inch ][250 mm 10 inch][ \_\_\_\_\_] diameter collars; each with locking butterfly balancing damper.

### 2.1.5 Hot-Water Heating Coil

Provide a copper tube heating coil, mechanically expanded into aluminum-plate fins. Heating coil must pass leak test underwater to 1380 kPa 200 psig.

### 2.1.6 Electric Heating Coil

Provide a factory installed and wired slip-in-type, open-coil design with integral control box. Include the following features:

- Primary and secondary over temperature protection

- Nickel chrome 80/20 heating elements

- Airflow switch

- Non-interlocking disconnect switch

- Fuses (for coils more than 48 A)

- Mercury contactors

- Pneumatic-electric switches and relays.

- Magnetic contactor for each step of control (for three-phase coils)

### 2.1.7 Electric Controls

Provide a 24 V damper actuator that is powered closed, powered open with microswitch to energize heating control circuit.

Provide a wall-mounting electric type thermostat with temperature display in Fahrenheit and Celsius, and with space temperature set point.

Provide a changeover thermostat of duct-mounting, electric type that reverses action of controls when duct temperature rises 21 degrees C 70 degrees F.

## 2.1.8 Electronic Controls

Provide a 24 V damper actuator that is powered closed, powered open

## 2.1.9 Pneumatic Controls

### 2.1.9.1 Pneumatic Damper Operator

Provide a [ 55 to 90 kPa8 to 13 psig][ 21 to 90 kPa3 to 13 psig] spring range.

### 2.1.9.2 Velocity Controllers

Provide a factory calibrated and field adjustable controller to minimum and maximum air volumes. Controllers must maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to wg 1000 Pa 4 inch when tested in accordance with ASHRAE 130. Controller must have a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

### 2.1.10 Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature. Thermostat must be time-proportional with reheat-coil control feature, and displays a temperature set-point display in Fahrenheit and Celsius. The auxiliary switch must energize heating control circuit. Changeover thermistor must have a reverse action feature.

## 2.2 DUAL-DUCT AIR TERMINAL UNITS

### 2.2.1 Configuration

Provide two volume dampers inside unit casing with mixing attenuator section and control components located inside a protective metal shroud.

### 2.2.2 Casing

Provide [ 0.85 mm steel0.034 inch][ 0.80 mm aluminum0.032 inch] casing. The casing must include an integral mixing baffle to efficiently mix the hot and cold airstream.

#### 2.2.2.1 Casing Lining

Provide 0.85 mm steel 0.034 inch casing. Provide 13 mm 1/2 inch thick, coated, fibrous-glass duct casing lining complying with ASTM C 1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 19 mm 3/4 inch thick adhesive of polyurethane foam insulation complying with 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. Any cut edges of fiberglass exposed to the airstream must be coated with NFPA 90A approved seal.

For the air inlet provide round stub connection for duct attachment. For the air outlet provide s-slip and drive connections. For access provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket.

### 2.2.3 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearings.

Perform a Maximum Damper Leakage Test in conformance to AHRI 880, for 3 percent of nominal airflow at [ 750 Pa3 inch wg] [ 1500 Pa6 inch wg] inlet static pressure.

Select either Damper Position, Hot Deck: normally [open] [closed] or Damper Position, Cold Deck: normally [closed] [open].

### 2.2.4 Attenuator Section

Provide [ 0.85 mm steel0.034 inch] [ 0.8 mm0.03 inch aluminum] sheet metal. Provide 13 mm1/2 inch thick, coated, fibrous-glass duct casing lining complying with ASTM C 1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 19 mm3/4 inch thick adhesive of polyurethane foam insulation complying with 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. Any cut edges of fiberglass exposed to the airstream must be coated with NFPA 90A approved seal.

### 2.2.5 Multi-Outlet Attenuator Section

Provide [two] [three] [four] [\_\_\_\_\_] [ 150 mm6 inch] 200 mm[8 inch] [ 250 mm10 inch] [\_\_\_\_\_] diameter collars; each with locking butterfly balancing damper.

### 2.2.6 Pneumatic Controls

#### 2.2.6.1 Pneumatic Damper Operator

Provide a [ 55 to 90 kPa8 to 13 psig] [ 21 to 90 kPa3 to 13 psig] spring range.

#### 2.2.6.2 Velocity Controllers

Provide a factory calibrated and field adjustable controller to minimum and maximum air volumes. Controllers must maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 1000 Pa 4 inch wg when tested in accordance with ASHRAE 130. Controller must have a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

#### 2.2.6.3 Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

### 2.2.7 Electronic Controls

#### 2.2.7.1 Damper Actuator

Provide a 24 V, powered closed, [spring return open] [powered open] damper

actuator.

#### 2.2.7.2 Velocity Control

Provide a factory calibrated controller to minimum and maximum air volumes, field adjustable at thermostat. Controller must maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 1000 Pa 4 inch wg, when tested in accordance with ASHRAE 130. Controller must have a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

#### 2.2.7.3 Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature. Thermostat must be time-proportional with reheat-coil control feature, and displays a temperature set-point display in Fahrenheit and Celsius.

#### 2.2.8 DDC Controls

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**NOTE: Select first paragraph and subparagraphs below when control components are packaged with the equipment.**  
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##### 2.2.8.1 Damper Actuators

Provide a 24 V, powered closed, [spring return open] [powered open] damper actuator.

##### 2.2.8.2 Velocity Sensors

Provide a multipoint array with velocity sensors in cold-deck and hot-deck air inlet and air outlet.

##### 2.2.8.3 Terminal Unit Controller

Provide a pressure independent, [variable-air] [constant] volume controller with electronic airflow transducers factory calibrated to minimum and maximum air volumes. Include the following features:

- Proportional, plus integral control of room temperature
- Time-proportional reheat-coil control
- Occupied and unoccupied operating mode
- Remote reset of airflow or temperature set points
- Adjusting and monitoring with portable terminal

##### 2.2.8.4 Room Sensor

Provide a wall mounting room sensor, with temperature set-point adjustment and access for connection of portable operator terminal.

### 2.2.9 Control Sequence

Modulate cold-air damper to maintain room temperature. Modulate warm-air damper to maintain constant airflow.

## 2.3 FAN-POWERED AIR TERMINAL UNITS

### 2.3.1 Configuration

Provide volume-damper assembly and fan in [series] [parallel] arrangement inside unit casing with control components inside a protective metal shroud.

### 2.3.2 Casing

Provide [ 0.85 mm steel0.034 inch] [ 0.80 mm aluminum0.032 inch] casing. The casing must include an integral mixing baffle to efficiently mix the hot and cold airstream.

#### 2.3.2.1 Casing Lining

Provide [ 13 mm1/2 inch] [ 19 mm3/4 inch] [ 25 mm1 inch] thick with 1.5 density, coated, fibrous-glass duct casing lining complying with ASTM C 1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 19 mm 3/4 inch thick adhesive of polyurethane foam insulation complying with 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. Any cut edges of fiberglass exposed to the airstream must be coated with NFPA 90A approved seal.

For the air inlet provide round stub connection for duct attachment. For the air outlet provide s-slip and drive connections. For access provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn gaskets.

### 2.3.3 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearings.

Perform a Maximum Damper Leakage Test in conformance to AHRI 880, for [2] [3] percent of nominal airflow at [ 750 Pa3 inch wg] [ 1500Pa6 inch wg] inlet static pressure, when tested in accordance with ASHRAE 130.

Select damper position: Normally [open] [closed].

### 2.3.4 Fan Section

Provide a galvanized-steel plenum, with direct-drive, forward-curved fan with air filter and backdraft damper.

#### 2.3.4.1 Lining

Provide [ 13 mm1/2 inch] [ 19 mm3/4 inch] [ 25 mm1 inch] thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

#### 2.3.4.2 Motor

Comply with requirements in Section 26 60 13.00 40 LOW-VOLTAGE MOTORS for [Multi-speed] [\_\_\_\_\_] motors. Motor must include a speed control feature that is adjustable Infinitely with pneumatic-electric and electronic controls. Fan-Motor Assembly must contain rubber isolators.

#### 2.3.4.3 Air Filter

[ 50 mm2 inch] [ 25 mm1 inch] thick, [fiberglass throwaway] [polyurethane].

#### 2.3.5 Attenuator Section

Provide [ 0.85 mm steel0.034 inch] [ 0.8 mm0.03 inch aluminum] sheet metal. Provide 1/2 inch 13 mm thick, coated, fibrous-glass duct casing lining complying with ASTM C 1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 19 mm 3/4 inch thick adhesive of polyurethane foam insulation complying with 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. Any cut edges of fiberglass exposed to the airstream must be coated with NFPA 90A approved seal.

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**NOTE: If heating coil is required, retain one of two paragraphs and associated subparagraphs below.**  
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#### 2.3.6 Hot-Water Heating Coil

Provide a copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig 1380 kPa; and factory installed.

#### 2.3.7 Electric Heating Coil

Provide a slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

Primary and secondary over-temperature protection

Nickel chrome 80/20 heating elements

Fan interlock contacts

Non-interlocking disconnect switch

Fuses (for coils more than 48 A)

Mercury contactors

Pneumatic-electric switches and relay

Magnetic contactor for each step of control (for three-phase coils)

### 2.3.8 Factory-Mounted and -Wired Controls

Mount electrical components in control box with removable cover. Incorporate single-point electrical connection to power source.

Factory mounted control transformer for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.

Fan and controls to terminal strip, and terminal lugs must match quantities, sizes, and materials of branch-circuit conductors for wiring terminations. Enclose terminal lugs in terminal box that is sized according to [NFPA 70](#).

Factory-mount a fused type disconnect switch.

### 2.3.9 Control Panel Enclosure

Conform to [NEMA 250](#), Type 1, with access panel sealed from airflow and mounted on side of unit.

### 2.3.10 Electric Controls

Provide a 24V damper actuator with wall-mounting electric thermostat and appropriate mounting hardware.

### 2.3.11 Pneumatic Controls

#### 2.3.11.1 Pneumatic Damper Operator

Provide a [ 55 to 90 kPa8 to 13 psig] [ 21 to 90 kPa3 to 13 psig] spring range.

#### 2.3.11.2 Velocity Controller

Provide a factory calibrated and field adjustable controller to minimum and maximum air volumes. Controllers must maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 1000 Pa 4 inch wg, when tested in accordance with [ASHRAE 130](#). Controller must have a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet.

#### 2.3.11.3 Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

### 2.3.12 Electronic Controls

Provide a bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor must be compatible with temperature controls and must have the following features:

Proportional, plus integral control of room temperature

Time-proportional reheat-coil control

Occupied and unoccupied operating mode

Remote reset of airflow or temperature set points

Adjusting and monitoring with portable terminal

Communication with temperature-control system

## 2.4 INDUCTION AIR TERMINAL UNITS

### 2.4.1 Configuration

Provide a volume-damper assembly inside unit casing with mechanical induction damper mounted on casing and control components located inside a protective metal shroud.

### 2.4.2 Casing

Provide [ 0.85 mm steel0.034 inch] [ 0.80 mm aluminum0.032 inch] casing. The casing must include an integral mixing baffle to efficiently mix the hot and cold airstream.

#### 2.4.2.1 Casing Lining

Provide [ 13 mm1/2 inch] [ 19 mm3/4 inch] [ 25 mm1 inch] thick, coated, fibrous-glass duct casing lining complying with ASTM C 1071. Secure with adhesive.

For the air inlet provide round stub connection for duct attachment. For the air outlet provide s-slip and drive connections [size matching inlet size]. For access provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket.

### 2.4.3 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearing.

Perform a Maximum Damper Leakage Test in conformance to AHRI 880, for [2] [3] percent of nominal airflow at [ 750 Pa3 inch wg] [ 1500 Pa6 inch wg] inlet static pressure, when tested in accordance with ASHRAE 130.

Select Damper Position, normally [open] [closed].

### 2.4.4 Induction Damper

Provide galvanized-steel, multi-blade assembly with self-lubricating bearings.

\*\*\*\*\*  
**NOTE: If heating coil is required, retain one of two paragraphs and associated subparagraphs below.**  
\*\*\*\*\*

### 2.4.5 Hot-Water Heating Coil

Provide a copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 1380 kPa 200 psig; and factory installed.

#### 2.4.6 Electric Heating Coil

Provide a slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

Primary and secondary over-temperature protection

Nickel chrome 80/20 heating elements

Airflow switch

Non-interlocking disconnect switch

Fuses (for coils more than 48 A)

Mercury contactors

Pneumatic-electric switches and relays

Magnetic contactor for each step of control (for three-phase coils)

#### 2.4.7 Pneumatic Controls

##### 2.4.7.1 Damper Operator

Provide a pneumatic, 35 to 70 kPa 5 to 10 psig spring range damper operator.

##### 2.4.7.2 Velocity Controller

Provide a factory calibrated and field adjustable to minimum and maximum air volumes; must maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 1000 Pa 4 inch wg, when tested in accordance with ASHRAE 130. Controller must have a multipoint velocity sensor at air inlet.

##### 2.4.7.3 Induction Damper Operator

Provide a pneumatic, spring range induction damper operator matching reset range of controller.

##### 2.4.7.4 Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

#### 2.4.8 Electronic Controls

##### 2.4.8.1 Damper Actuator

Provide a pneumatic, 35 to 70 kPa 5 to 10 psig spring range damper operator.

##### 2.4.8.2 Velocity Controller

Provide a factory calibrated and field adjustable to minimum and maximum air volumes; must maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 1000 Pa 4 inch wg when tested in accordance with ASHRAE 130, and must have a multipoint velocity sensor at air inlet.

#### 2.4.8.3 Induction Damper Operator

Provide a pneumatic, spring range induction damper operator matching reset range of controller.

#### 2.4.8.4 Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware with the following features:

Proportional, plus integral control of room temperature

Time-proportional reheat-coil control

Temperature set-point display in Fahrenheit and Celsius

### 2.5 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

#### 2.5.1 Configuration

Provide a volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

#### 2.5.2 Casing

Provide [ 0.85 mm steel 0.034 inch] [ 0.80 mm 0.032 inch aluminum] casing. The casing must include an integral mixing baffle to efficiently mix the hot and cold airstream.

##### 2.5.2.1 Casing Lining

Provide [ 13 mm 1/2 inch] [ 19 mm 3/4 inch] [ 25 mm 1 inch] thick, coated, fibrous-glass duct casing lining complying with ASTM C 1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 19 mm thick 3/4 inch adhesive of polyurethane foam insulation complying with 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. Any cut edges of fiberglass exposed to the airstream must be coated with NFPA 90A approved seal.

For the air inlet provide round stub connection for duct attachment. For the air outlet provide s-slip and drive connections. For access provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket.

\*\*\*\*\*  
**NOTE: Retain one of first two paragraphs and associated subparagraphs below; retain first for units with mechanical volume regulators.**  
\*\*\*\*\*

#### 2.5.3 Regulator Assembly

Provide [extruded-aluminum] [galvanized-steel] components with key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.

### 2.5.3.1 Automatic Flow-Control Assembly

Match combined spring rates for each volume-regulator size with machined dashpot for stable operation. Provide factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

\*\*\*\*\*  
**NOTE: Retain first paragraph below for units with system-air-powered volume regulators.**  
\*\*\*\*\*

### 2.5.4 Regulator Assembly

Provide system-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows must operate at temperatures from 18 to plus 60 deg C 0 to 140 deg F minus. Bellows must be impervious to moisture and fungus, and must be suitable for 2500 Pa10 inch wg static pressure, when tested in accordance with ASHRAE 130, and must be factory tested for leaks.

### 2.5.5 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearings.

Perform a Maximum Damper Leakage Test in conformance to AHRI 880, for [2] [3] percent of nominal airflow at [ 750 Pa3 inch wg] [ 1500 Pa6 inch wg] inlet static pressure, when tested in accordance with ASHRAE 130.

Select Damper Position, normally [open] [closed].

### 2.5.6 Attenuator Section

Provide [ 0.85 mm steel0.034 inch] [ 0.8 mm0.03 inch aluminum] sheet metal.

Provide 13 mm 1/2 inch thick, coated, fibrous-glass duct casing lining complying with ASTM C 1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 19 mm 3/4 inch thick adhesive of polyurethane foam insulation complying with 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. Any cut edges of fiberglass exposed to the airstream must be coated with NFPA 90A approved seal.

### 2.5.7 Multi-Outlet Attenuator Section

Provide [two] [three] [four] [\_\_\_\_\_] [ 150 mm6 inch] [ 200 mm8 inch] [ 250 mm10 inch] [\_\_\_\_\_] diameter collars; each with locking butterfly balancing damper.

\*\*\*\*\*  
**NOTE: If heating coil is required, retain one of two paragraphs and associated subparagraphs below.**  
\*\*\*\*\*

### 2.5.8 Hot-Water Heating Coil

Provide a copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig 1380 kPa; and factory installed.

### 2.5.9 Electric Heating Coil

Provide a slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

Primary and secondary over-temperature protection

Nickel chrome 80/20 heating elements

Airflow switch

Non-interlocking disconnect switch

Fuses (for coils more than 48 A)

Mercury contactors

Pneumatic-electric switches and relays

Magnetic contactor for each step of control (for three-phase coils)

\*\*\*\*\*  
**NOTE: Retain one of five paragraphs and associated subparagraphs below.**  
\*\*\*\*\*

### 2.5.10 Electric Controls

#### 2.5.10.1 Damper Actuator

Provide a 24 V, powered closed, [spring return open] [powered open] damper actuator.

#### 2.5.10.2 Thermostat

Provide a wall-mounting electronic type thermostat with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.

### 2.5.11 Pneumatic Controls

#### 2.5.11.1 Pneumatic Damper Operator

Provide a 55 to 90 kPa[8 to 13 psig] [ 21 to 90 kPa3 to 13 psig] spring range.

#### 2.5.11.2 Velocity Controllers

Provide a factory calibrated and field adjustable controller to minimum and maximum air volumes. Controllers must maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 1000 Pa 4 inch wg, when tested in accordance with ASHRAE 130. Controller must have a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

### 2.5.11.3 Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

### 2.5.12 Electronic Controls

Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor must be compatible with temperature controls specified.

#### 2.5.12.1 Damper Actuator

Provide a 24 V, powered closed, [spring return open] [powered open] damper actuator.

#### 2.5.12.2 Velocity Controller

Provide a factory calibrated controller to minimum and maximum air volumes, field adjustable at thermostat. Controller must maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 1000 Pa 4 inch wg, when tested in accordance with ASHRAE 130. Controller must have a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

#### 2.5.12.3 Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature. Thermostat must be time-proportional with reheat-coil control feature, and displays a temperature set-point display in Fahrenheit and Celsius.

\*\*\*\*\*  
**NOTE: Select first paragraph and subparagraphs  
below when control components are packaged with the  
equipment.**  
\*\*\*\*\*

### 2.5.13 DDC Controls

Bidirectional damper operators and microprocessor-based controller and room sensor must be compatible with temperature controls specified.

#### 2.5.13.1 Damper Actuators

Provide a 24 V, powered closed, [spring return open] [powered open] damper actuator.

#### 2.5.13.2 Terminal Unit Controller

Provide a pressure independent, [variable-air] [constant] volume controller with electronic airflow transducers factory calibrated to minimum and maximum air volumes. Include the following features:

Proportional, plus integral control of room temperature

Time-proportional reheat-coil control

Occupied and unoccupied operating mode

Remote reset of airflow or temperature set points

Adjusting and monitoring with portable terminal

2.5.13.3 Room Sensor

Provide a wall mounting room sensor, with temperature set-point adjustment and access for connection of portable operator terminal.

2.5.14 Control Sequence

Make suitable for operation with duct pressures between 60 and 750 Pa 0.25 and 3.0 inch wg inlet static pressure. Provide a factory-mounted and -piped, 5-micron filter; velocity-resetting, adjustable, high-limit control, with amplifying relay. Provide a system-powered, wall-mounting thermostat.

2.6 INTEGRAL-DIFFUSER AIR TERMINAL UNITS

2.6.1 Configuration

Provide a volume-damper assembly inside unit casing with [integral] [attached] [linear-slot] [square-ceiling] [louver-face] [perforated] diffuser.

2.6.2 Casing

Provide [ 0.85 mm 0.034 inch steel] [ 0.80 mm 0.032 inch aluminum] casing. The casing must include an integral mixing baffle to efficiently mix the hot and cold airstream.

2.6.2.1 Casing Lining

Provide 0.85 mm 0.034 inch steel casing. Provide 13 mm 1/2 inch thick, coated, fibrous-glass duct casing lining complying with ASTM C 1071. Secure with adhesive. For the air inlet provide round stub connection for duct attachment.

2.6.3 Volume Damper

Provide galvanized steel with peripheral gasket and self-lubricating bearings.

Damper Position: Normally [open] [closed].

2.6.4 Diffuser

Provide a galvanized-steel insulated plenum with extruded-aluminum or sheet-steel diffuser, having fixed or variable geometry designed to operate from 100 percent to minimum airflow, manual adjustment of airflow direction, and white baked-enamel finish.

\*\*\*\*\*  
**NOTE: Retain one of three paragraphs and associated subparagraphs below.**  
\*\*\*\*\*

## 2.6.5 Electric Controls

### 2.6.5.1 Damper Actuator

Provide a 24 V, powered closed, [spring return open] [powered open].

### 2.6.5.2 Thermostat

Provide a wall-mounting electronic type thermostat with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.

## 2.6.6 Pneumatic Controls

Damper operator [, velocity controller,] and thermostat must be compatible with temperature controls specified.

### 2.6.6.1 Pneumatic Damper Operator

Provide a [ 55 to 90 kPa8 to 13 psig] [ 21 to 90 kPa3 to 13 psig] spring range.

### 2.6.6.2 Velocity Controller

Provide a factory calibrated and field adjustable velocity controller to minimum and maximum air volumes. Controller must maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 1000 Pa 4 inch wg when tested in accordance with ASHRAE 130. Controller must have a multipoint velocity sensor at air inlet.

### 2.6.6.3 Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

## 2.6.7 Electronic Controls

Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor must be compatible with temperature controls specified.

### 2.6.7.1 Damper Actuator

Provide a 24 V, powered closed, [spring return open] [powered open].

### 2.6.7.2 Velocity Controller

Provide a factory calibrated and field adjustable to minimum and maximum air volumes. Controller must maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 1000 Pa 4 inch wg when tested in accordance with ASHRAE 130. Controller must have a multipoint velocity sensor at air inlet.

### 2.6.7.3 Thermostatt

Provide a wall-mounting electronic type thermostat with integral control of room temperature. Thermostat must be time-proportional with reheat-coil

control feature, and displays a temperature set-point display in Fahrenheit and Celsius.

\*\*\*\*\*  
**NOTE: Retain paragraph and subparagraphs below for units with system-powered controls.**  
\*\*\*\*\*

#### 2.6.8 Control Sequence

Make suitable for operation with duct pressures between 60 and 750 Pa 0.25 and 3.0inch wg inlet static pressure. Provide factory-mounted and -piped, 5-micron filter; velocity-resetting, adjustable, high-limit control; and amplifying relay with a system-powered, wall-mounting thermostat.

#### 2.7 HIGH-PRESSURE DUAL-DUCT MIXING BOXES

Provide mechanical constant-volume control type units with a mechanical controller that is operated by the entering mixed-airstream and maintains a constant airflow through the unit.

[Units must be factory preset to deliver air volumes indicated.]

##### 2.7.1 Construction

Unit must be factory assembled, complete with casing, air mixing valve assembly, single air mixing valve operator, and mechanical constant-volume control, ready for field mounting and connection to control.

Casing exterior must be not less than 0.040 inch 1 millimeter thick aluminum, or 20 gage mill-galvanized steel with not less than 380 grams per square meter 1.25 ounces of zinc per square foot of two-sided surface, conforming to ASTM A 653/A 653M.

Casing interior must be acoustically baffled and lined with fibrous glass thick enough to attain required sound power level performance and preclude condensation on any exterior surface, but in no case less than 25 millimeter 1 inch. Air side of fibrous glass must be chloroprene-impregnated and manufactured to resist delamination or surface erosion at air velocities to 20 meter per second 4,000 feet per minute. Liner edges exposed to airstream must be protected by metal turnovers. Liner and fibrous-glass baffle material must conform to NFPA 90A.

Inlet valves and connecting linkage must be constructed for modulation by a single operator. Hot inlet valve must be normally open, and the cold inlet valve must be normally closed. Hot and cold inlet ports must be field reversible.

[Mechanical constant-volume control must be externally adjustable and must have a cubic meter per second feet-per-minute graduated capacity scale, which also indicates minimum/maximum range of the unit.]

[Mechanical constant-volume control must be externally adjustable. A calibration chart must be provided with each unit indicating capacity per revolution of mechanical constant-volume device. Each unit must be labeled with minimum/maximum volume range to facilitate field adjustment.]

Components subject to friction must have oil-impregnated bronze bearings, graphite-impregnated or lubricant-impregnated nylon bearings; and

lubricant-impregnated elastomers, corrosion-resistant steel, and similar materials.

Casing must be fitted with rigid, airtight access panels, easily removable and of ample size to give free access to interior parts. Closure must be achieved by spring-retained, quarter-turn, slotted-cam captive devices, or similar operating fasteners.

Calking compounds must be chloroprene, polyurethane polysulfides, or silicone elastomers. Gaskets must be chloroprene, polyurethane, or vinyl.

#### 2.7.2 Casing Leakage

Casing joints must be sealed to prevent leakage of more than 2 percent of rated capacity with all connections sealed and with an internal static pressure of 250 pascal 1 inch wg.

#### 2.7.3 Inlet Valve Leakage

Leakage in fully closed valve position must not exceed 2 percent of unit rated capacity against inlet pressure of 2000 pascal 8 inches wg.

#### 2.7.4 Mixed-Air Temperature Requirements

A thermometer traverse of all unit outlets must show variation of not more than 5 percent of the difference, at the time, between the temperatures of equal quantities of cold and warm airstreams entering the unit.

#### 2.7.5 Volume Control Requirements

Mechanical constant-volume control must maintain design volume within plus or minus 5 percent, regardless of the modulation position of inlet valves or the fluctuation of inlet or outlet pressure, within limits of indicated minimum pressure.

#### 2.7.6 Sound Level Requirements

\*\*\*\*\*

**NOTE: Select the first of the two paragraphs pertaining to airborne noise only when acceptable NC levels or space attenuation requirements are not a part of the specification.**

**Select the second of the two paragraphs pertaining to airborne noise as well as casing radiated noise when acceptable NC levels or space attenuation requirements are not a part of the specification.**

**Rewrite if ceiling construction sound transmission loss is different from that specified. NC 40 must be specified as a limiting factor when no criteria are specified.**

\*\*\*\*\*

[When determining equipment sound-power level performance and when no space-attenuation criteria are given, 18 dB space attenuation must be assumed in all octave bands. Manufacturer must design and incorporate sound correction factors for equipment.]

[Unit must meet the airborne and radiated sound-power level (PWL) requirements scheduled, to attain the specified NC levels. An 18 dB space attenuation must be assumed in all octave bands with consideration given to downstream duct construction and configuration in determining airborne NC levels.]

The following ceiling sound-transmission loss (TL) characteristics, based on 25 millimeter 1 inch acoustic lay-in panels and T-bar suspension, must be assumed in computing resultant space radiated NC levels:

<u>OCTAVE BAND</u>	<u>2ND</u>	<u>3RD</u>	<u>4TH</u>	<u>5TH</u>	<u>6TH</u>	<u>7TH</u>
PWL-TL	-2	-4	-9	-10	-13	-15

[NC40 must be the limiting factor.]

### 2.7.7 Control Requirements

Operating-control power source must be dry, compressed air of instrument quality at 100 kilopascal 15 pounds per square inch, gage, unless otherwise approved.

Air mixing valve operator must be provided by the automatic temperature control manufacturer and installed by the unit manufacturer, unless field installation for specific construction is approved. Operator must be controlled by a direct-acting thermostat.

Pneumatic control tubing must be copper and must be brought to the exterior of the casing for connection to automatic temperature control system.

### 2.8 LOW-PRESSURE DUAL-DUCT MIXING BOXES

\*\*\*\*\*  
**NOTE: Drawings and schedules must portray system dynamics so that equipment functions as required.**  
 \*\*\*\*\*

Units must be manual-damper volume control type. A calibration chart must be provided with each unit. Each unit must be labeled with capacity minimum/maximum range to facilitate field adjustment.

Volume control damper must be externally adjustable over an inlet pressure range of 12 to 250 pascal 0.05 to 1 inch wg.

Components subject to friction must have oil-impregnated bronze bearings, graphite-impregnated nylon bearings, and lubricant-impregnated elastomers, corrosion-resistant steel, and similar materials.

Casing must be fitted with rigid, airtight access panels, easily removable, and of ample size to give free access to interior parts. Closure must be achieved by spring-retained, quarter-turn, slotted-cam captive devices or similar operating fasteners.

Calking compounds must be chloroprene, polyurethane polysulfides, or silicone elastomers. Gaskets must be chloroprene, polyurethane, or vinyl.

#### 2.8.1 Casing Leakage

Casing joints must be sealed to prevent leakage of more than 2 percent of

rated capacity, with all connections sealed and with an internal static pressure of 250 pascal 1 inch wg.

#### 2.8.2 Inlet Valve Leakage

Leakage in fully closed valve position must not exceed 2 percent of unit rated capacity against inlet pressure of 250 pascal 1 inch wg.

#### 2.8.3 Mixed-Air Temperature Requirements

A thermometer traverse of all unit outlets must show variation of not more than 5 percent of the difference, at the time, between the temperatures of equal quantities of cold and warm airstreams entering the unit.

#### 2.8.4 Sound Level Requirements

\*\*\*\*\*  
**NOTE: When no acceptable noise criteria level is specified, NC 40 must be specified as the limiting factor.**  
\*\*\*\*\*

When determining equipment sound power level performance when no space-attenuation criteria are given, 18 dB space attenuation must be assumed in all octave bands. Manufacturer must design and incorporate sound correction factors for equipment.

#### 2.8.5 Control Requirements

Operating-control power source must be dry, compressed air of instrument quality at 100 kilopascal 15 psig, unless otherwise approved.

Air mixing valve operator must be provided by the automatic temperature control manufacturer and installed by the unit manufacturer, unless field installation for specific construction is approved. Operator must be controlled by a direct-acting thermostat.

Pneumatic control tubing must be copper and must be brought to the exterior of the casing for connection to automatic temperature control system.

### 2.9 SOURCE QUALITY CONTROL

#### 2.9.1 Identification

Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

#### 2.9.2 Verification of Performance

Rate air terminal units according to AHRI 880.

## PART 3 EXECUTION

### 3.1 INSTALLATION

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

### 3.2 CONNECTIONS

Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

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

#### 3.2.1 Hot-Water Piping

Connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

Connect ducts to air terminal units.

Ground units with electric heating coils.

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-486B](#).

### 3.3 OPERATION AND MAINTENANCE

Contractor shall submit [6] [\_\_\_\_\_] copies of the [Operation and Maintenance Manuals](#) 30 calendar days prior to testing the following items. Data must be updated and resubmitted for final approval no later than 30 calendar days prior to contract completion.

### 3.4 FIELD QUALITY CONTROL

\*\*\*\*\*  
**NOTE: Retain first paragraph below to require a factory-authorized service representative to perform, or assist Contractor with, field inspections, tests, and adjustments. Retain one of two options to suit Project; delete both to require only an inspection before field testing.**  
\*\*\*\*\*

Engage a factory-authorized service representative to inspect[, test, and adjust] field-assembled components and equipment installation, including connections[, and to assist in field testing]. Report results in writing.

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

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

\*\*\*\*\*  
**NOTE: Retain first paragraph below for air terminal units with hot-water coils.**  
\*\*\*\*\*

#### 3.4.1 Leak Test

After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

### 3.4.2 Operational Test

After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

Remove and replace malfunctioning units and retest as specified above.

### 3.5 STARTUP SERVICE

\*\*\*\*\*  
**NOTE: Delete this Article if factory-authorized  
service representative is not required.**  
\*\*\*\*\*

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

Complete installation and startup checks according to manufacturer's written instructions and do the following:

Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.

Verify that controls and control enclosure are accessible.

Verify that control connections are complete.

Verify that nameplate and identification tag are visible.

Verify that controls respond to inputs as specified.

### 3.6 DEMONSTRATION

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

-- End of Section --