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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 36 00.00 40

AIR TERMINAL UNITS

05/16

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SECTION 23 36 00.00 40

AIR TERMINAL UNITS
05/16

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NOTE: This guide 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.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

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

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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PART 1 GENERAL

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NOTE: Clearly portray system dynamics in drawings and schedules so that equipment functions as required.

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NOTE: If Section 23 30 00 HVAC AIR DISTRIBUTION is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.

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Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

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 Reference Identifier (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 DUCT COUNCIL (ADC)

ADC Standards Manual	(2008; 5th Edition) Flexible Duct Performance Installation Standards

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 880 I-P	(2011) Performance Rating of 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 A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building

Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 181	(2013; Reprint Apr 2017) UL Standard for Safety Factory-Made Air Ducts and Air Connectors
UL 486A-486B	(2018) UL Standard for Safety Wire Connectors

1.2 ADMINISTRATIVE REQUIREMENTS

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, communication and security systems,and partition assemblies.

1.2.1 Pre-Installation Meetings

Submit itemized lists for all materials, equipment, and fixtures to be incorporated in the work [30][_____] days prior to commencement of work. Ensure list includes manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information. Submit product data for each type of air terminal unit indicated, including rated capacities, furnished specialties, sound-power ratings, and accessories:

[a. Bypass Single-Duct Air Terminal Units

][b. Dual-Duct Air Terminal Units

][c. Fan-Powered Air Terminal Units

][d. Induction Air Terminal Units

][e. Shutoff Single-Duct Air Terminal Units

][f. Integral-Diffuser Air Terminal Units

][g. High-Pressure Dual-Duct Mixing Boxes

][h. Low-Pressure Dual-Duct Mixing Boxes

] Submit records of existing conditions 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 constitutes acceptance of existing conditions.

Submit shop drawings which detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection. 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.

Provide units with the configuration, capacity, and static-pressure characteristics indicated.

Ensure dimensional data stated constitutes nominal sizing, which has been adjusted by the manufacturer when necessary to accommodate acoustic material thickness.

Ensure units proposed are identical to units having at least 2 years of proven satisfactory field service.

****

NOTE: Select or delete the following paragraph after checking current "Directory of Air Diffusion Council (ADC Standards Manual) Certified Products."

****

Provide certification that units and the list of spare parts are ADC Standards Manual tested and rated.

1.3 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals

required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification 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

SD-02 Shop Drawings

Bypass Single-Duct Air Terminal Units; G[, [____]]

Dual-Duct Air Terminal Units; G[, [____]]

Fan-Powered Air Terminal Units; G[, [____]]

Induction Air Terminal Units; G[, [____]]

Shutoff Single-Duct Air Terminal Units; G[, [____]]

Integral-Diffuser Air Terminal Units; G[, [____]]

High-Pressure Dual-Duct Mixing Boxes; G[, [____]]

Low-Pressure Dual-Duct Mixing Boxes; G[, [____]]

SD-03 Product Data

Bypass Single-Duct Air Terminal Units; G[, [____]]

Dual-Duct Air Terminal Units; G[, [____]]

Fan-Powered Air Terminal Units; G[, [____]]

Induction Air Terminal Units; G[, [____]]

Shutoff Single-Duct Air Terminal Units; G[, [____]]

Integral-Diffuser Air Terminal Units; G[, [____]]

High-Pressure Dual-Duct Mixing Boxes; G[, [____]]

Low-Pressure Dual-Duct Mixing Boxes; G[, [____]]

SD-06 Test Reports

Test Report

SD-07 Certificates

List of Spare Parts

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Record Drawings

1.4 QUALITY CONTROL

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

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

Ensure Air Terminals are certified under the AHRI 880 I-P Certification Program and carry the ARI Seal.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Verification of Performance

Rate air terminal units according to AHRI 880 I-P.

2.1.2 Bypass Single-Duct Air Terminal Units

2.1.2.1 Configuration

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

2.1.2.2 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 C1071. Secure with adhesive. For the air inlet, provide round stub connection for duct attachment. For the air outlet, provide s-slip and drive connections. Provide removable panels, with airtight gaskets, for access to diverter and other parts requiring service, adjustment, or maintenance.

2.1.2.3 Diverter Assembly

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

2.1.2.4 Multi-Outlet Attenuator Section

Provide [two][three][four][_____],[150 mm][200 mm][250 mm][6-inch][8-inch][10-inch][_____] diameter collars, each with locking butterfly balancing damper.

2.1.2.5 Hot-Water Heating Coil

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

2.1.2.6 Electric Heating Coil

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

a. Primary and secondary over temperature protection

b. Nickel chrome 80/20 heating elements

c. Airflow switch

d. Non-interlocking disconnect switch

[e. Fuses (for coils more than 48 A)

] f. Mercury contactors

g. Pneumatic-electric switches and relays.

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

[2.1.2.7 Electric Controls

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

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

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

][2.1.2.8 Electronic Controls

Provide a 24 V damper actuator that is powered closed and powered open.

][2.1.2.9 Pneumatic Controls

Provide a pneumatic damper operator with a[55 to 90 kPa 8 to 13 psig][21 to 90 kPa 3 to 13 psig] spring range.

Provide a factory calibrated and field adjustable velocity controller capable of handling minimum and maximum air volumes. Ensure controllers maintain a constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to wg 1000 Pa 4-inches wg when tested in accordance with ASHRAE 130. Provide

controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlets and air outlets.

]2.1.2.10 Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature. Ensure thermostat is time-proportional type with a reheat-coil control feature. Display temperature set-points in Celsius and Fahrenheit. Ensure the auxiliary switch energizes the heating control circuit, and changeover thermistor has a reverse action feature.

2.1.3 Dual-Duct Air Terminal Units

2.1.3.1 Configuration

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

2.1.3.2 Casing

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

a. 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 C1071. 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 E84. Coat any cut edges of fiberglass exposed to the airstream with a 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. Provide removable panels with an airtight gasket for access to the diverter and other parts requiring service, adjustment, or maintenance.

2.1.3.3 Volume Damper

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

Perform a Maximum Damper Leakage Test (MDLT) in conformance to AHRI 880 I-P, for 3 percent of nominal airflow at[750 Pa 3-inch wg][1500 Pa 6-inch wg] inlet static pressure.

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

2.1.3.4 Attenuator Section

Provide[0.85 mm steel 0.034-inch][0.8 mm 0.03-inch aluminum] sheet metal. Provide 13 mm 1/2-inch thick, coated, fibrous-glass duct casing

lining complying with ASTM C1071. 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 E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

2.1.3.5 Multi-Outlet Attenuator Section

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

2.1.3.6 Pneumatic Controls

a. Pneumatic Damper Operator

Provide a pneumatic damper operator with a[55 to 90 kPa 8 to 13 psig][21 to 90 kPa 3 to 13 psig] spring range.

b. Velocity Controllers

Provide a factory calibrated velocity controller, field adjustable to minimum and maximum air volumes. Ensure controllers 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. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

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

2.1.3.7 Electronic Controls

a. Damper Actuator

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

b. Velocity Control

Provide a factory calibrated controller, with settings for minimum and maximum air volumes, and field adjustable at thermostat. Ensure controller maintains 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. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting electronic type thermostat with integral control

of room temperature, time-proportional with reheat-coil control feature. Provide a temperature set-point display in Celsius and Fahrenheit.

[2.1.3.8 DDC Controls

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

a. Damper Actuators

Provide a 24 V, powered closed, powered open damper actuator.

b. Velocity Sensors

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

c. 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:

(1) Proportional, plus integral control of room temperature

(2) Time-proportional reheat-coil control

(3) Occupied and unoccupied operating mode

(4) Remote reset of airflow or temperature set points

(5) Adjusting and monitoring with portable terminal

d. Room Sensor

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

]2.1.3.9 Control Sequence

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

2.1.4 Fan-Powered Air Terminal Units

2.1.4.1 Configuration

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

2.1.4.2 Casing

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

a. Casing Lining

Provide[13 mm 1/2-inch][19 mm 3/4-inch][25 mm 1-inch] thick with 24 kg per cubic meter 1.5 pounds per cubic foot density, coated, fibrous-glass duct casing lining complying with ASTM C1071. 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 E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

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

2.1.4.3 Volume Damper

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

Perform a Maximum Damper Leakage Test (MDLT) in conformance to AHRI 880 I-P, for [2][3] percent of nominal airflow at[750 Pa 3-inch wg][1500 Pa 6-inch wg] inlet static pressure, when tested in accordance with ASHRAE 130.

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

2.1.4.4 Fan Section

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

a. Lining

Provide[13 mm 1/2-inch][19 mm 3/4-inch][25 mm 1-inch] thick, coated, fibrous-glass duct liner complying with ASTM C1071; secured with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

b. Motor

Comply with requirements in Section 26 60 13.00 40 LOW-VOLTAGE MOTORS for [Multi-speed] [_____] motors. Provide motor which includes a speed control feature that is infinitely adjustable with pneumatic-electric and electronic controls. Provide rubber isolators with fan-motor assembly.

c. Air Filter

Provide[50 mm 2-inch][25 mm 1-inch] thick, [fiberglass throwaway] [polyurethane] air-filter.

2.1.4.5 Attenuator Section

Provide[0.85 mm steel 0.034-inch][0.8 mm 0.03-inch aluminum] sheet

metal. Provide 13 mm thick 1/2-inch, coated, fibrous-glass duct casing lining complying with ASTM C1071. 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 E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

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

[2.1.4.6 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.

][2.1.4.7 Electric Heating Coil

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

a. Primary and secondary over-temperature protection

b. Nickel chrome 80/20 heating elements

c. Fan interlock contacts

d. Non-interlocking disconnect switch

e. Fuses (for coils more than 48 A)

f. Mercury contactors

g. Pneumatic-electric switches and relay

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

]2.1.4.8 Factory-Mounted and -Wired Controls

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

Provide 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.

Provide fan and controls to terminal strip, with terminal lugs which 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.

2.1.4.9 Control Panel Enclosure

Provide control panel enclosure conforming to NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

2.1.4.10 Electric Controls

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

2.1.4.11 Pneumatic Controls

a. Pneumatic Damper Operator

Provide a pneumatic damper operator with a[55 to 90 kPa 8 to 13 psig][21 to 90 kPa 3 to 13 psig] spring range.

b. Velocity Controllers

Provide a factory calibrated velocity controller, field adjustable to minimum and maximum air volumes. Ensure controllers 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. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

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

2.1.4.12 Electronic Controls

Provide a bi-directional damper operator and microprocessor-based controller with integral airflow transducer and room sensor compatible with temperature controls, having the following features:

a. Proportional, plus integral control of room temperature

b. Time-proportional reheat-coil control

c. Occupied and unoccupied operating mode

d. Remote reset of airflow or temperature set points

e. Adjusting and monitoring with portable terminal

f. Communication with temperature-control system

2.1.5 Induction Air Terminal Units

2.1.5.1 Configuration

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

2.1.5.2 Casing

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

a. 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 C1071. 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]. Provide removable panels with an airtight gasket, for access to diverter and other parts requiring service, adjustment, or maintenance.

2.1.5.3 Volume Damper

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

Perform a Maximum Damper Leakage Test (MDLT) in conformance to AHRI 880 I-P, for [2][3] percent of nominal airflow at[750 Pa 3-inch wg][1500 Pa 6-inch wg] inlet static pressure, when tested in accordance with ASHRAE 130.

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

2.1.5.4 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.

****

2.1.5.5 Hot-Water Heating Coil

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

2.1.5.6 Electric Heating Coil

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

a. Primary and secondary over-temperature protection

b. Nickel chrome 80/20 heating elements

c. Airflow switch

d. Non-interlocking disconnect switch

e. Fuses (for coils more than 48 A)

f. Mercury contactors

g. Pneumatic-electric switches and relays

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

2.1.5.7 Pneumatic Controls

a. Damper Operator

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

b. Velocity Controller

Provide a factory calibrated velocity controller; field adjustable to minimum and maximum air volumes. Ensure controller is capable of maintaining constant airflow dictated by a 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. Ensure controller has a multipoint velocity sensor at air inlet.

c. Induction Damper Operator

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

d. Thermostat

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

2.1.5.8 Electronic Controls

a. Damper Actuator

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

b. Velocity Controller

Provide a factory calibrated velocity controller; field adjustable to minimum and maximum air volumes. Ensure controller is capable of maintaining 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. Ensure controller has a multipoint velocity sensor at air inlet.

c. Induction Damper Operator

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

d. Thermostat

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

(1) Proportional, plus integral control of room temperature

(2) Time-proportional reheat-coil control

(3) Temperature set-point display in Celsius and Fahrenheit

2.1.6 Shutoff Single-Duct Air Terminal Units

2.1.6.1 Configuration

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

2.1.6.2 Casing

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

a. 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 C1071. 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 E84. Coat any cut edges of fiberglass exposed to the airstream 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. 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.

****

[2.1.6.3 Regulator Assembly

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

a. 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.

****

][2.1.6.4 Regulator Assembly

Provide system-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Ensure the bellows operate at temperatures from 18 to plus 60 degrees C 0 to 140 degrees F; are impervious to moisture and fungus; are suitable for 2500 Pa 10-inch wg static pressure when tested in accordance with ASHRAE 130, and are factory tested for leaks.

]2.1.6.5 Volume Damper

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

Perform a Maximum Damper Leakage Test (MDLT)in conformance to AHRI 880 I-P, for [2][3] percent of nominal airflow at[750 Pa 3-inch wg][1500 Pa 6-inch wg] inlet static pressure when tested in accordance with ASHRAE 130.

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

2.1.6.6 Attenuator Section

Provide[0.85 mm steel 0.034-inch][0.8 mm 0.03-inch aluminum] sheet metal attenuator section.

Provide 13 mm 1/2-inch thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. 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 E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

2.1.6.7 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.

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

[2.1.6.8 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.

][2.1.6.9 Electric Heating Coil

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

a. Primary and secondary over-temperature protection

b. Nickel chrome 80/20 heating elements

c. Airflow switch

d. Non-interlocking disconnect switch

[e. Fuses (for coils more than 48 A)

] f. Mercury contactors

g. Pneumatic-electric switches and relays

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

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

]2.1.6.10 Electric Controls

a. Damper Actuator

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

b. Thermostat

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

2.1.6.11 Pneumatic Controls

a. Pneumatic Damper Operator

Provide a[55 to 90 kPa 8 to 13 psig][21 to 90 kPa 3 to 13 psig] spring range.

b. Velocity Controllers

Provide a factory calibrated controller, field adjustable to minimum and maximum air volumes. Ensure controllers 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. Ensure controller has a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

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

2.1.6.12 Electronic Controls

Provide bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer. Ensure room sensor is compatible with

temperature controls specified.

a. Damper Actuator

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

b. Velocity Controller

Provide a factory calibrated controller set to minimum and maximum air volumes, field adjustable at thermostat. Ensure controller maintains 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. Ensure controller has a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

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

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

[2.1.6.13 DDC Controls

Provide bidirectional damper operators and microprocessor-based controller. Provide with room sensor that is compatible with temperature controls specified.

a. Damper Actuators

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

b. 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:

(1) Proportional, plus integral control of room temperature

(2) Time-proportional reheat-coil control

(3) Occupied and unoccupied operating mode

(4) Remote reset of airflow or temperature set points

(5) Adjusting and monitoring with portable terminal

(6) Room Sensor

Provide a wall mounting room sensor, with temperature set-point adjustment

and access for connection of portable operator terminal.

]2.1.6.14 Control Sequence

Make suitable for operation with duct pressures between60 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.

2.1.7 Integral-Diffuser Air Terminal Units

2.1.7.1 Configuration

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

2.1.7.2 Casing

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

a. 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 C1071. Secure with adhesive. For the air inlet provide round stub connection for duct attachment.

2.1.7.3 Volume Damper

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

Damper Position: Normally [open] [closed].

2.1.7.4 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 a baked-enamel finish].

****

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

****

[2.1.7.5 Electric Controls

a. Damper Actuator

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

b. Thermostat

Provide a wall-mounting electronic type thermostat with clock display,

temperature display in Celsius and Fahrenheit, and space temperature set point.

][2.1.7.6 Pneumatic Controls

Provide damper operator[, velocity controller,] and thermostat compatible with temperature controls specified.

a. Pneumatic Damper Operator

Provide a[55 to 90 kPa 8 to 13 psig][21 to 90 kPa 3 to 13 psig] spring range.

b. Velocity Controller

Provide a factory calibrated velocity controller, which is field adjustable to minimum and maximum air volumes capable of maintaining 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. Ensure controller has a multipoint velocity sensor at air inlet.

c. Thermostat

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

][2.1.7.7 Electronic Controls

Provide bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer. Provide with room sensor that is compatible with temperature controls specified.

a. Damper Actuator

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

b. Velocity Controller

Provide a factory calibrated velocity controller, field adjustable to minimum and maximum air volumes. Ensure controller is capable of maintaining 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. Provide controller with a multipoint velocity sensor at air inlet.

c. Thermostat

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

****

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

****

]2.1.7.8 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 factory-mounted and -piped, 5-micron filter; velocity-resetting, adjustable, high-limit control; and amplifying relay with a system-powered, wall-mounting thermostat.

2.1.8 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.

[Provide factory preset units to deliver air volumes indicated.

]2.1.8.1 Construction

Provide factory assembled units, 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.

Verify casing exterior is not less than 1 millimeter 0.040-inch 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 A653/A653M.

Ensure casing interior is 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. Verify air side of fibrous glass is chloroprene-impregnated and manufactured to resist delamination or surface erosion at air velocities to 20 meter per second 4,000-feet per minute. Ensure liner edges exposed to airstream are protected by metal turnovers. Verify liner and fibrous-glass baffle material conforms to NFPA 90A.

Ensure inlet valves and connecting linkage are constructed for modulation by a single operator. Verify hot inlet valve is normally open, and the cold inlet valve is normally closed. Ensure hot and cold inlet ports are field reversible.

[Verify mechanical constant-volume control is externally adjustable and has a cubic meter per second feet-per-minute graduated capacity scale, which also indicates minimum/maximum range of the unit.

][Ensure mechanical constant-volume control is externally adjustable. Provide a calibration chart with each unit indicating capacity per revolution of mechanical constant-volume device. Clearly label each unit with minimum/maximum volume range to facilitate field adjustment.

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

Ensure casing is fitted with rigid, airtight access panels, easily removable and of ample size to give free access to interior parts. Verify closure is achieved by spring-retained, quarter-turn, slotted-cam captive devices, or similar operating fasteners.

Verify that all caulking compounds are chloroprene, polyurethane polysulfides, or silicone elastomers, with chloroprene, polyurethane, or vinyl gaskets.

2.1.8.2 Casing Leakage

Verify casing joints are 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.

2.1.8.3 Inlet Valve Leakage

Verify leakage in fully closed valve position does not exceed 2 percent of unit rated capacity against inlet pressure of 2000 pascal 8-inches wg.

2.1.8.4 Mixed-Air Temperature Requirements

Verify that a thermometer traverse of all unit outlets shows 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.

2.1.8.5 Volume Control Requirements

Verify mechanical constant-volume control maintains 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.

2.1.8.6 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. Specify NC 40 as a limiting factor when no other criteria are specified.

****

[When determining equipment sound-power level performance and when no space-attenuation criteria are given, assume 18 dB space attenuation in all octave bands. Verify manufacturer's design incorporates sound correction factors for equipment.

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

] Assume the following ceiling sound-transmission loss (TL) characteristics,

based on 25 millimeter 1-inch acoustic lay-in panels and T-bar suspension, in computing resultant space radiated NC levels:

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

[NC40 is the limiting factor.

]2.1.8.7 Control Requirements

Ensure operating-control power source is dry, compressed air of instrument quality at 100 kilopascal 15 psig, unless otherwise approved.

Provide for an air mixing valve operator from the automatic temperature control manufacturer, and installation by the unit manufacturer, unless field installation for specific construction is pre-approved by the Contracting Officer. Ensure operator is controlled by a direct-acting thermostat.

Provide copper pneumatic control tubing brought to the exterior of the casing for connection to automatic temperature control system.

[2.1.9 Low-Pressure Dual-Duct Mixing Boxes

****
NOTE: Ensure drawings and schedules portray system dynamics so that equipment functions as required.
****

Provide manual-damper volume control type units. Provide a calibration chart with each unit. Label each unit with capacity minimum/maximum range to facilitate field adjustment.

Verify volume control damper is externally adjustable over an inlet pressure range of 12 to 250 pascal 0.05 to 1-inch wg.

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

Ensure casings are fitted with rigid, airtight access panels, easily removable, and of ample size to give free access to interior parts. Provide closure mechanism which is achieved by spring-retained, quarter-turn, slotted-cam captive devices or similar operating fasteners.

Provide caulking compounds which are chloroprene, polyurethane polysulfides, or silicone elastomers. Provide chloroprene, polyurethane, or vinyl gaskets.

2.1.9.1 Casing Leakage

Seal all casing joints 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.

2.1.9.2 Inlet Valve Leakage

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

2.1.9.3 Mixed-Air Temperature Requirements

Ensure a thermometer traverse of all unit outlets shows 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.

2.1.9.4 Sound Level Requirements

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

When determining equipment sound power level performance when no space-attenuation criteria are given, assume 18 dB space attenuation in all octave bands. Verify manufacturer designs incorporates sound correction factors for equipment.

2.1.9.5 Control Requirements

Ensure operating-control power source is dry, compressed air of instrument quality at 100 kilopascal 15 psig, unless otherwise approved.

Provide an air mixing valve operator from the automatic temperature control manufacturer and install using the unit manufacturer, unless field installation for specific construction is pre-approved by the Contracting Officer. Ensure operator is controlled by a direct-acting thermostat.

Provide copper pneumatic control tubing brought to the exterior of the casing for connection to the automatic temperature control system.

]PART 3 EXECUTION

3.1 INSTALLATION

Install air terminal units level and plumb, and in accordance with NFPA 90A. Maintain sufficient clearance for normal service and maintenance.

3.1.1 Identification

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

3.1.2 Connections

Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems.

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

3.1.2.1 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.

3.2 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].

][Perform the following field tests and inspections and prepare a test report.

] 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.
****

3.2.1 Leak Test

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

3.2.2 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.

3.3 SYSTEM STARTUP

****
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:

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

b. Verify that controls and control enclosure are accessible.

c. Verify that control connections are complete.

d. Verify that nameplate and identification tag are visible.

e. Verify that controls respond to inputs as specified.

3.4 CLOSEOUT ACTIVITIES

3.4.1 Operation and Maintenance

Submit [6][_____] copies of the operation and maintenance manuals 30 calendar days prior to testing the following items. Update and re-submit data for final approval no later than 30 calendar days prior to contract completion. Concurrently, submit record drawings providing current factual information, including deviations and amendments to the drawings, and concealed and visible changes in the work.

3.4.2 Demonstration

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

-- End of Section --