
USACE / NAVFAC / AFCEA UFGS-15810N (February 2004)

Preparing Activity: NAVFAC Superseding
UFGS-15810N (August 2003)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 23 June 2005

Latest change indicated by CHG tags

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DIVISION 15 - MECHANICAL

SECTION 15810N

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02/04

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SECTION 15810N

DUCTWORK AND DUCTWORK ACCESSORIES 02/04

NOTE: This guide specification covers the requirements for ductwork and ductwork accessories including diffusers, registers, grilles, louvers, dampers, and louvered penthouses.

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).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

NOTE: This guide specification does not include air distribution and handling equipment, such as air curtains, air handlers, fans, fan-coil room units, induction units, variable-air-volume terminal units, power roof ventilators, gravity ventilators, and unit ventilators. It does not cover industrial ductwork such as dust collection systems. It does not cover and should not be used for local exhaust ventilation systems. Local exhaust systems are appropriate for the containment/removal of containments encountered in hazardous work place atmospheres. Consult Section 11501 INDUSTRIAL VENTILATION AND EXHAUST SYSTEMS (DUCTS AND FANS), for guidance regarding local exhaust system.

PART 1 GENERAL

1.1 REFERENCES

NOTE: Issue (date) of references included in
project specifications need not be more current than
provided by the latest guide specification. Use of
SpecsIntact automated reference checking is
recommended for projects based on older guide
specifications.

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 MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

| | |
|------------|--|
| AMCA 500-D | (1998) Laboratory Methods of Testing Dampers for Rating |
| AMCA 501 | (2003) Application Manual for Air Louvers |

ASTM INTERNATIONAL (ASTM)

| | |
|-------------------|---|
| ASTM A 167 | (2004) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip |
| ASTM A 653/A 653M | (2004a) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process |
| ASTM B 152/B 152M | (2000) Copper Sheet, Strip, Plate, and Rolled Bar |
| ASTM B 209 | (2004) Aluminum and Aluminum-Alloy Sheet and Plate |
| ASTM B 209M | (2004) Aluminum and Aluminum-Alloy Sheet and Plate (Metric) |
| ASTM C 1071 | (2000) Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material) |
| ASTM C 423 | (2002a) Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method |
| ASTM C 553 | (2002) Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications |
| ASTM E 437 | (1992; R 1997) Industrial Wire Cloth and Screens (Square Opening Series) |
| ASTM E 90 | (2004) Laboratory Measurement of Airborne |

Sound Transmission Loss of Building
Partitions and Elements

ASTM E 96

(2000e1) Water Vapor Transmission of
Materials

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A

(2002) Installation of Air Conditioning
and Ventilating Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION
(SMACNA)

SMACNA FGDCS

(2003, 7th Ed) Fibrous Glass Duct
Construction Standards

SMACNA HVAC Duct Const Stds

(1995, 2nd Ed) HVAC Duct Construction
Standards - Metal and Flexible

SMACNA Seismic Restraint Mnl

(1998, 2nd Ed) Seismic Restraint Manual:
Guidelines for Mechanical Systems

UNDERWRITERS LABORATORIES (UL)

UL 181

(2005) Factory-Made Air Ducts and Air
Connectors

UL 555

(1999; Rev thru Jan 2002) Fire Dampers

UL 555S

(1999; Rev thru Apr 2003) Smoke Dampers

UL 723

(2003) Test for Surface Burning
Characteristics of Building Materials

1.2 RELATED REQUIREMENTS

Section 15050N BASIC MECHANICAL MATERIALS NAD METHODS, applies to this
section with the additions and modifications specified herein.

1.3 PRESSURE CLASSIFICATION

NOTE: In the contract drawings, the designer must
identify the portion of each duct system to be
constructed for a particular pressure classification
or the entire system to be assigned a pressure
classification. Where no designations are provided,
the 250 Pa one inch water gage is the basis of
compliance, except variable air volume (VAV) ducts
upstream of VAV boxes has a 500 Pa two inch water
gage basis of compliance.

SMACNA HVAC Duct Const Stds, Section 1, and as indicated.

1.4 SYSTEM DESCRIPTION

Provide ductwork systems including ductwork, ductwork hangers and supports,

equipment, materials, installation, workmanship, fabrication, assembly, erection, and inspection, shall be in accordance with SMACNA HVAC Duct Const Stds as modified and supplemented by the specifications and drawings.

1.4.1 Design Requirements

1.4.1.1 Duct Span Versus Reinforcement Schedule

Submit maximum duct dimension, board stiffness rating, board thickness, type and spacing of reinforcement, and maximum duct static pressure.

1.4.1.2 Louvered Penthouse

Submit test report for withstanding 200 km/hr 125 mph wind force.

1.4.1.3 Automatic Dampers

Submit certification of damper leakage testing and conformance with AMCA 500-D and specified maximum leakage or pressure drop requirements.

1.4.1.4 Sound Pressure Level Rating

Submit for inlets and outlets including diffusers, registers and grilles.

1.4.1.5 Sound Attenuators and Attenuator Ducts Acoustical Tests

Submit certified test data from an independent acoustical testing laboratory, listing sound noise reduction characteristics, static pressure drop, air flow velocity capacity, and insertion loss data.

1.4.1.6 Plenum or Casing Acoustical Tests

Submit as required in paragraph entitled "Casings and Plenums."

1.5 SUBMITTALS

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

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.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

NOTE: Delete items in brackets when fiberglass duct is not used.

SD-01 Preconstruction Submittals

Diffusers, registers, and grilles

[Duct hangers and supports]

Submit a schedule of inlets and outlets indicating location, catalog model number, manufacturer, dimensional information, sound pressure level rating, nominal rated volumetric flow rate liter per second (L/s) cfm, neck or face velocity at specified L/s cfm, pressure drop at specified L/scfm, throw and drop for outlets, range for diffusers, and maximum and minimum L/s cfm modulation.

SD-02 Shop Drawings

Locations of test holes

[Duct hangers and supports details]

[Fibrous glass ducts fabrication and reinforcement details]

SD-03 Product Data

Dampers

Fire dampers

Automatic Smoke-Fire Dampers

Automatic smoke dampers

Sound attenuators

Acoustical duct lining

[Flexible ducts and connectors
Fibrous glass ducts]
Insulation and vapor barrier
Duct-liner adhesives
Louvers
Louvered penthouse
Bird screens
Diffusers, registers, and grilles
Troffers
Metal ducts
Test holes
Sound-attenuator ducts

Submit method of closure data for fibrous glass ductwork.

SD-05 Design Data

Duct span versus reinforcement schedule

SD-06 Test Reports

Louvered penthouse
Automatic dampers
Sound pressure level rating
Louvers
Sound attenuators and attenuator ducts acoustical tests
Plenum or casing acoustical tests

SD-08 Manufacturer's Instructions

Ductwork and ductwork accessories

SD-11 Closeout Submittals

Fibrous glass ducts

Upon completion, and before final acceptance of work, submit a statement signed by a representative of the fibrous glass ductwork manufacturer that installation is in accordance with the specifications and manufacturer's prescribed procedures and techniques.

1.6 QUALITY ASSURANCE

1.6.1 Qualification of Installer for Fibrous Glass Ductwork

NOTE: Delete this paragraph if there is no fibrous glass ductwork.

Install ductwork by a firm approved by the fibrous glass ductwork manufacturer. Provide a certified personnel list from the manufacturer, as qualified to fabricate and install the system. Personnel not on the list will not be permitted to fabricate or install the ductwork system.

1.6.2 Daily Report for Fibrous Glass Ductwork

NOTE: Delete this paragraph if there is no fibrous glass ductwork.

Provide a daily written report listing the personnel fabricating and installing the ductwork system. State in the report whether or not the condition and quality of the materials provided were satisfactory in all respects.

1.6.3 Modification of References

NOTE: No negative pressure construction for 1000, 1500, or 2500 Pa 4, 6, or 10 inch water gage is provided herein.

SMACNA Duct Construction Manuals: The SMACNA recommendations shall be considered as mandatory requirements. Substitute the word "shall" for the word "should" in these manuals.

1.6.4 Ductwork and Ductwork Accessories

Submit manufacturer's instruction including job inspection checklist, methods of on-site storage and handling, and recommended repair methods.

PART 2 PRODUCTS

2.1 METAL DUCTS

2.1.1 Steel Ducts

ASTM A 653/A 653M galvanized steel sheet, lock-forming quality; coating designation G90.

2.1.2 Aluminum Ducts

ASTM B 209MASTM B 209 alloy 3003-H14 for aluminum sheet and alloy 6061-T6 or equivalent strength for aluminum connectors and bar stock.

2.1.3 Copper Sheets

ASTM B 152/B 152M, light cold rolled temper.

2.1.4 Corrosion Resisting (Stainless) Steel Sheets

ASTM A 167.

2.1.5 Duct-Liner Adhesives

Fire-resistant adhesive.

2.2 DUCTS OF PRESSURE CLASSES

NOTE: Do not use insulation liners for ductwork at infectious areas in hospitals, such as operational suites, nurseries, pathological facilities, intensive care units, and surgical wards; use factory prefabricated sound attenuators instead. For brig facilities, fibrous glass ductwork should not be used in inmate housing area, areas accessible to inmates, nor areas with concrete, gypsum board, or plaster ceilings. Do not use fibrous glass ducts within 300 mm 12 inches of electric or fuel fired heaters.

Ducts of pressure classes 1000 to 2500 Pa 4 to 10 inch water gage.
Construct ducts of [galvanized steel] [stainless steel].

2.2.1 Construction

Provide duct construction, metal gages, and hangers and support reinforcements.. Ducts shall not pulsate or vibrate when in operation. Pressure sensitive tape shall not be used as a primary sealant on ductwork. Air leakage shall be less than one percent of the system capacity. Curved elbows shall have a centerline radius not less than 1 1/2 times the width of ducts.

2.2.2 Joints

Construct joints to meet the requirements of the leakage test specified herein. Duct components shall fit so that joints are not mismatched. Do not use duct sealant and tape to compensate for mismatched connections. Longitudinal locks or seams known as "button-punch snap-lock" will not be permitted. Apply fire-resistant sealing compound to exposed male part of fittings collars so that sealer will be on inside of joint and fully protected by the metal of the duct and fitting. Apply one brush coat of sealing compound over outside of joint to at least 50 mm 2 inchband width covering screwheads and joint gap. When tape is used, apply a single wrap of a duct tape over the wet sealer. Tape provided shall be as recommended by the sealer manufacturer to permit proper curing of the sealer. Dents in the male portion of the slip fitting collar will not be acceptable.

2.2.3 Fittings

Provide square elbows, round elbows, fittings, branch take-offs, transitions, splitters, duct volume dampers, fire dampers, flexible

connections, and access doors.

2.2.3.1 Test Holes

Provide factory fabricated, airtight, and noncorrosive test holes with screw cap and gasket. Provide extended neck fittings to clear insulation.

2.2.3.2 Round Elbows

Provide 45 degree and 90 degree elbows of 2 piece die stamped construction for ducts 200 mm 8 inches or less in diameter. For ducts over 200 mm 8 inches in diameter, provide 5 mitered piece for 90 degrees and 3 mitered piece for 45 degrees.

2.2.4 Round and Oval Ducts

Make joints between sections of duct and fittings with mating angle rings, beaded sleeve joints or slide-on gasketed flange connections. Slide-on gasketed flange joints shall consist of two mating flange rings. The flanges shall be fabricated with an integral mastic to make them self-sealing. The flanges shall be joined to the duct with spot-welds or self-tapping screws. A neoprene gasket shall be used between the flanges. Final joining of the slide-on flange connection shall be made with four bolts for flat-oval ducts. A single-bolt closure ring shall be used to complete the round slide-on flange connection.

2.2.5 Rectangular Ducts

Except as specified or indicated otherwise, make joints between sections of duct and between ducts and fittings with mating angle flange joints, other joints recommended in SMACNA HVAC Duct Const Stds, Section 1, or slide-on gasketed flange connections. Reinforce at the joints and between the joints. The slide-on gasketed flange connections shall consist of two mating flange frames. The frames shall be made up from four pieces of straight roll formed flange and four corner pieces. The flange shall be fabricated with an integral mastic to make them self sealing. The corner pieces shall be made with a downset to allow the corner of the duct to protrude past the corner piece. The frame shall be joined to the ductwall with spotwelds or self-tapping screws. A butyl gasket shall be used between the flanges. Gasket must pass UL 723 and shall not contain vegetable oils, fish oils or any other type vehicle that will support fungal and/or bacterial growth associated with dark areas of ductwork. The connection shall be completed using drive-on corner clips and snap-on cleat. Cleat spacing and fastener spacing shall be as dictated by the manufacturer. For joint systems, follow the manufacturer's construction and installation guidelines.

2.2.6 Sound Attenuators (Traps)

Provide factory fabricated attenuators that will reduce the rated sound pressure level of the fan down to at least 65 decibels in the 250 Hz (3rd octave band) center frequency by using a reference sound source calibrated in decibels of sound power at 10-12 watts. Maximum permissible pressure drop shall not exceed 160 Pa 0.63 inch of water. Attenuators to be constructed air-tight when operating under an internal pressure of 2500 Pa 10 inches of water. The air-side surface shall be capable of withstanding air velocity of 50 meters per second 10,000 feet per minute. When attenuators are submitted for approval, provide manufacturer's certification of the sound reduction values. Sound absorbing material

shall conform with ASTM C 1071, Type I or II. Provide suitable duct-transition sections for connection to ductwork.

2.2.6.1 Net Noise Reduction Values

Conform with the following:

Minimum Net Noise Reduction Values,
Sound Pressure Level dB
(Reference Sound Power at 10-12 Watts)

| Octave Pass Band | 2 | 3 | 4 | 5 | 6 | 7 |
|-----------------------|-----|-----|-----|------|------|------|
| Center-Frequency (Hz) | 125 | 250 | 500 | 1000 | 2000 | 4000 |
| Noise Reduction (dB) | 11 | 16 | 19 | 30 | 40 | 32 |

2.2.6.2 Factory-Fabricated Sound Attenuators (Traps)

Provide sound attenuators constructed of galvanized sheet steel casing and sound absorbing material covered with an internal perforated zinc-coated metal liner. Sound absorbing materials shall be faced with glass fiber cloth and hold in compression to prevent settling. The internal perforated metal liner shall be not less than 24 gage, with perforations not larger than 4 mm 5/32 inch in diameter providing a net open area not less than 22 percent of the surface. Attenuators shall be insulated to prevent sweating. Attenuators shall be acoustically tested with metal duct inlet and outlet sections while under the rated air flow conditions. Noise reduction data shall include effects of flanking paths and vibration transmission.

2.2.6.3 Factory-Fabricated Sound-Attenuator Ducts

Sound-attenuator ducts may be provided in lieu of sound attenuators (traps). Comply with requirements specified herein for sound attenuators. Construct each double-walled duct and fitting of an outer zinc-coated metal pressure shell with 25 mm one inch thick acoustical blanket insulation and an internal perforated zinc-coated metal liner. Install sufficient length of run to obtain the noise reduction value specified. Furnish certification from manufacturer stating that the sound reduction value specified will be obtained within the length of duct run provided. The internal perforated zinc-coated metal liner shall be not less than 24 gage, unless ribbed, then not less than 28 gage for the duct liner and not less than 26 gage for the fitting liner with perforations not larger than 2.40 mm 3/32 inch diameter. Seal joints as specified in paragraph entitled "Round and Oval Ducts." [Rigid molded fiber-glass inserts with the air side surface [PVC] [neoprene]-coated, when complying with requirements specified herein, may be used in lieu of internal perforated zinc-coated metal liner.]

2.2.7 Safety Relief Valve

Provide negative pressure safety relief valve indicated. Valve shall be the standard product of duct and fitting manufacturer.

2.2.8 Air Valves

Provide [manual] [or] [normally open, automatic] air valves for pressure reducing or volume control on single duct systems. [Provide manufacturer's standard linkage and motor mounted platform to accommodate pneumatic actuators.] Construct valves of corrosion-resistant materials. Frame, links, and levers may be of zinc-coated steel. Vanes, pivots, hinges or

knuckle joints may be of aluminum or other non-ferrous metal. Valves shall close with maximum leakage of 0.15 or 0.26 meter per second 30 or 52 fpm average velocity over the valve face area at 250 or 750 Pa one or 3 inch water column corresponding static pressure on high pressure side of the valve.

2.3 DUCTS OF PRESSURE CLASSES 750 Pa 3 INCH WATER GAGE OR LESS

NOTE: Do not use insulation liners for ductwork at infectious areas in hospitals, such as operational suites, nurseries, pathological facilities, intensive care units, and surgical wards; use factory prefabricated sound attenuators instead. For brig facilities, fibrous glass ductwork should not be used in inmate housing area, areas accessible to inmates, nor areas with concrete, gypsum board, or plaster ceilings. Do not use fibrous glass ducts within 300 mm 12 inches of electric or fuel fired heaters.

Except as specified or indicated otherwise, construction, metal gage, hangers and supports, and reinforcements shall conform with SMACNA HVAC Duct Const Stds, except that ducts with pressure classifications below 500 Pa 2 inch water gage that are located outside of the conditioned space shall have a seal class C. Ductwork shall be airtight and shall not vibrate or pulsate when system is in operation. Pressure sensitive tape shall not be used as a primary sealant on ductwork with pressure classifications above 250 Pa one inch water gage. Air leakage shall be less than 5 percent of the system capacity. Construct ductwork of [galvanized steel] [or] [aluminum].

2.3.1 Curved Elbows

Make a centerline radius not less than 1 1/2 times the width or diameter of the duct.

2.3.2 Laps

Make laps at joints in the direction of air flow. Space button-punch or bolt-connection in standing seams at fixed centers not greater than 150 mm 6 inches. Longitudinal locks or seams, known as "button-punch snap-lock," may be used in lieu of Pittsburgh Lock [, but will not be permitted on aluminum ducts].

2.3.3 Fittings

Provide elbows, vaned elbows, take-offs, branch connections, transitions, splitters, volume dampers, fire dampers, flexible connections, and access doors. Provide factory fabricated airtight, and noncorrosive test holes with screw cap and gasket.

2.3.4 Acoustical Attenuator Systems

2.3.4.1 Acoustical Duct Lining

NOTE: When internal lining is shown, the designer

shall size sheetmetal ductwork on the drawings to
compensate for the lining thickness.

Flexible or rigid mineral fiber lining conforming to ASTM C 1071. Lining shall not be less than 25 mm one inch thick.

2.3.4.2 Net Noise Reduction Values

Conform with the following:

Minimum Net Noise Reduction Values,
Sound Pressure Level dB
(Reference Sound Power at 10-12 Watts)

| Octave Pass Band | 2 | 3 | 4 | 5 | 6 | 7 |
|-----------------------|-----|-----|-----|------|------|------|
| Center-Frequency (Hz) | 125 | 250 | 500 | 1000 | 2000 | 4000 |
| Noise Reduction (dB) | 11 | 16 | 19 | 30 | 40 | 32 |

2.3.4.3 Preformed Duct Liner

Preformed round duct liner designed for insertion in round ducts may be used in the sizes commercially available. Provide duct liner sections with slip-lap joints not less than 50 mm 2 inches wide. Make joints in accordance with manufacturer's printed instructions. Furnish fire-resistant adhesive to field-coated joints when recommended by the manufacturer to prevent delamination or erosion at joints. Tubular sections of duct liner shall fit the metal duct snugly and without gaps between duct-liner sections.

2.3.4.4 Factory-Fabricated Sound-Attenuator Ducts

Sound-attenuator ducts may be provided in lieu of sound attenuators. Comply with requirements specified herein for sound attenuators. Provide double-walled duct and fitting of an outer zinc-coated metal pressure shell with 25 mm one inch thick acoustical blanket insulation and an internal perforated zinc-coated metal liner. Install sufficient length of run to obtain the noise reduction value specified. Furnish certification from manufacturer that the sound reduction values specified will be obtained within the length of duct run provided. The internal perforated zinc-coated metal-liner shall be not less than 24 gage, unless ribbed, then not less than 28 gage for the duct liner and not less than 26 gage for the fitting liner with perforations not larger than 2.40 mm 3/32 inch diameter.

Seal joints as specified in paragraph entitled "Round and Oval Ducts." [Rigid molded fiber-glass inserts with the air side surface [PVC] [neoprene]-coated, if complying with all requirements specified herein, may be used in lieu of internal perforated zinc-coated metal liner.]

2.3.4.5 Sound Attenuators (Traps)

Provide factory-fabricated attenuators constructed of galvanized steel sheets. Outer casing shall be not less than 22 gage. Acoustical fills shall be mineral fiber conforming to ASTM C 1071. Air flow capacities shall be as indicated. Pressure drops through attenuators shall not exceed values indicated, or shall be not in excess of 15 percent of the total external static pressure of the air handling system, whichever is less. Acoustically test sound attenuators with metal duct inlet and outlet sections while under rated air flow conditions. Noise reduction data shall include effects of flanking paths and vibration transmission. Attenuators

shall be airtight when operating at internal static pressure not less than 500 Pa 2 inches water gage. Conform with noise reduction requirements specified in paragraph entitled "Net Noise Reduction Values."

2.4 FLEXIBLE DUCTS AND CONNECTORS

NOTE: Care should be taken not to locate flexible ductwork in prisoner housing areas, areas accessible to prisoners, or areas with concrete, gypsum board or plaster ceilings.

UL 181, Class I, UL listed, and additional requirements herein specified. Provide to connect between rigid ducts and outlets or terminals. There shall be no erosion, delamination, loose fibers, or odors from the ducts into the air stream. At 120 degrees C 250 degrees F, minimum rating pressures shall be [1500 Pa positive and 125 Pa negative, up to 20 meters per second] [6 inches water positive and 1/2 inch negative, up to 4,000 fpm] [_____] [and] [500 Pa positive and 125 Pa negative, up to 13 meters per second] [2 inches water positive and 1/2 inch negative, up to 2500 fpm] [_____] . Flexible ducts shall be maximum [1] [2] [2 1/2] meters [4] [6] [8] feet in length. Minimum bend radius shall be twice the duct diameter.

2.4.1 Materials

Interlocking spiral or helically corrugated type constructed of [zinc-coated steel,] [corrosion-resistant steel], [aluminum,] [or] [noncollapsible fire-retardant, chloroprene or chlorosulfonated polyethylene impregnated, minimum one kilogram per square meter 30 ounces per square yard] woven mineral fabric.

2.4.2 Insulation and Vapor Barrier

ASTM C 553 Type 1, Class B-2, minimum 25 mm one inch nominal thickness and 12 kilogram per cubic meter three-quarter lb./cu. ft. density. Sheathe insulation with a vapor barrier having a maximum water vapor permeance of 0.20 perm in accordance with ASTM E 96, Procedure A. Coat ends of insulation with cement to prevent erosion and delamination.

2.4.3 Joints

Make airtight slip joints, seal with pressure-sensitive vapor-seal adhesive tape or duct sealer, and secure with sheet metal screws. To prevent insulation compression, place 50 mm wide by 25 mm thick 2 inch wide by one inch thick closed cell foam plastic spacers over joints under vapor barriers. To provide a vaportight joint, provide a [zinc-coated steel] [corrosion-resistant steel] [or] [aluminum] clamp over such spacers.

2.5 CASINGS AND PLENUMS

Factory fabricated components with field installation. Furnish certified testing data from plenum or casing manufacturer obtainable directly from an independent acoustical laboratory, listing sound absorption and transmission loss characteristics of panel assembly. Sound absorption coefficients and sound transmission loss, determined by an independent laboratory, shall be in accordance with ASTM C 423 and ASTM E 90 respectively.

[2.6 FIBROUS GLASS DUCTS

NOTE: Do not use insulation liners for ductwork at infectious areas in hospitals, such as operational suites, nurseries, pathological facilities, intensive care units, and surgical wards; use factory prefabricated sound attenuators instead. For brig facilities, fibrous glass ductwork should not be used in inmate housing area, areas accessible to inmates, nor areas with concrete, gypsum board, or plaster ceilings. Do not use fibrous glass ducts within 300 mm 12 inches of electric or fuel fired heaters.

At the Contractor's option, rigid fibrous glass ductwork may be provided in lieu of metal ductwork. Provide factory fabricated molded round sections or flat sheets of resin bonded inert inorganic fibrous glass, faced with an external vapor barrier, conforming to UL 181, Class 1, NFPA 90A, and SMACNA FGDCS with the following general properties:

- a. Thickness: Minimum 25 mm one inch;
- b. Stiffness (Product of Young' Modulus, E, and Moment of Inertia, I), EI: 3275 kPa 475 pounds per square inch;
- c. Thermal Conductivity: Maximum 0.036 watt per meter per degree K 0.25 Btu inch per square foot per degrees F per hour; and
- d. Permeance: 0.02 maximum.

]2.7 DIFFUSERS, REGISTERS, AND GRILLES

2.7.1 Material and Finishes

Provide factory-furnished diffusers, registers, and grilles constructed of [steel] [or] [aluminum]. Exterior and exposed edges shall be rolled, or otherwise stiffened and rounded. [Steel parts shall be factory zinc phosphate treated prior to priming and painting or have a baked-on enamel finish.] Colors shall be selected or approved by Contracting Officer. [For ductwork of pressure classes 1000 to 2500 Pa 4 to 10 inch water gage, provide sponge-rubber gasket between flanges and wall or ceiling.]

2.7.2 Sound Pressure Level

NOTE: The designer must observe that the standard 10 dB attenuation of sound power level takes into consideration the various types of room effects and ceiling transmission losses of the design place. See details in ASHRAE "Handbook of Fundamentals." Recommended permissible room sound pressure levels are as follows:

| NC Range, dB | Typical Application |
|--------------|---|
| 20-25 | Church Sanctuary, Concert and Opera Halls, |

| NC Range, dB | Typical Application Sound Reproduction Studios, Private Home |
|--------------|--|
| 25-30 | Legitimate Theaters, Board Rooms, Conference Rooms |
| 30-35 | Private Office, Ball-Rooms, Banquet Rooms, Hospital Rooms, Movie Theaters, School Classrooms, Libraries, Lecture Hall |
| 30-35 | Prisoner Housing/Brig |
| 35-40 | Public Libraries, Building Lobbies, School Laboratories, Restaurants, General Offices, Gymnasium |
| 40-45 | Halls and Corridors, Cafeterias, Retail Store |
| 40-60 | Computer Room |
| 45-50 | Supermarkets and Department Stores (Main Floor), Restaurant Kitchens, Commissary |
| 45-75 | Manufacturing Area, Light |
| 55-75 | Manufacturing Area, Heavy |

Manufacturer certified sound pressure level rating of inlets and outlets.
Conform with the following permissible room sound pressure levels:

| NC Range, dB | Typical Application |
|--------------|---------------------|
| [_____] | [_____] |

2.7.3 Throw

The distance from the diffuser, register, or grille to the point which the air velocity falls below [0.25] [0.50] [0.64] [1.00] meter per second [50] [100] [125] [200] feet per minute [_____] shall not exceed [1.5] [_____] times the outlet mounting height.

2.7.4 Drop

Maximum drop of air stream shall not be within [1.50] [1.83] meters [5] [6]

feet [_____] of the floor at the end of the throw.

2.7.5 Ceiling Diffusers

Equip with baffles or other devices required to provide proper air distribution pattern [as indicated]. Provide factory-fabricated, single key, volume dampers. Except for linear diffusers, internal parts shall be removable through the diffuser neck for access to the duct and without the use of special tools.

2.7.5.1 Circular, Square, and Rectangular Diffusers

Construct each ceiling diffuser of four or more concentric elements designed to deliver air in a generally horizontal direction without excess smudging of the ceiling. Interior elements of square and rectangular ceiling diffusers may be circular, square, or rectangular as manufacturer's standard.

2.7.5.2 Perforated Plate Diffusers

Provide adjustable [one-way,] [two-way,] [three-way,] [or] [four-way] air pattern controls as indicated. Diffuser faceplates shall not sag or deflect when operating under design conditions.

2.7.5.3 Linear Diffusers

Joints between diffuser sections shall appear as hairline cracks. Provide alignment slots for insertion of key strips or other concealed means to align exposed butt edges of diffusers. [Equip with plaster frames when mounted in plaster ceiling.] Do not use screws and bolts in exposed face of frames or flanges. Frames and flanges exposed below ceiling shall be metal-filled and ground smooth. Furnish separate pivoted or hinged adjustable air-volume-damper and separate air-deflection blades.

[2.7.5.4 Security Ceiling Diffusers

NOTE: Use this paragraph for brig facilities only.

Diffusers shall be steel with faceplate, fixed diffusion louvers, flat surface margin, and an opposed blade damper. Faceplate shall be 14 gage minimum with 15 by 15 mm holes on 5 mm 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

]2.7.6 Registers

Double-deflection supply registers. [Provide manufacturer-furnished volume dampers. Volume dampers shall be of the group-operated, opposed-blade type and key adjustable by inserting key through face of register. Operating mechanism shall not project through any part of the register face. Automatic volume control devices will be acceptable.] [Provide exhaust and return registers as specified for supply registers, except that exhaust and return registers shall have a single set of nondirectional face bars or vanes having the same appearance as the supply registers.] [Set face bars or vanes at [_____] degrees.]

[2.7.6.1 Security Supply Air Registers Except in Cells

NOTE: Use this paragraph for brig facilities only.

Supply air registers, except in prisoner cells and prisoner holding cells, shall be steel with individually adjustable horizontal and vertical vanes, perforated faceplate, flat surface margin and opposed blade damper. Vertical vanes shall be in front; vane spacing shall be 20 mm 3/4 inch o.c. Perforated faceplate shall be 14 gage (minimum) with 15 by 15 mm holes on 5 mm 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

] [2.7.6.2 Security Return and Other Air Registers Except in Cells

NOTE: Use this paragraph for brig facilities only.

Return, exhaust, transfer and relief air registers, except in prisoner cells and prisoner holding cells, shall be steel with perforated faceplate, flat surface margin, opposed blade damper, and duct mounting sleeve. Faceplate shall be 14 gage (minimum) with 15 by 15 mm holes on 5 mm 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

] [2.7.6.3 Security Supply Air Registers in Cells

NOTE: Use this paragraph for brig facilities only.

Supply air registers in prisoner cells and prisoner holding cells shall be steel with perforated faceplate, flat surface margin, extension sleeve, opposed blade damper, and back mounting flanges. Faceplate shall be 14 gage (minimum) with 15 by 15 mm holes on 5 mm 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent. Wall sleeve shall be 14 gage (minimum).

] [2.7.6.4 Security Return and Other Type Air Registers in Cells

NOTE: Use this paragraph for brig facilities only.

Return, exhaust, transfer and relief air registers in prisoner cells and prisoner holding cells shall be steel with perforated faceplate, flat surface margin, wall sleeve, opposed blade damper, and back mounting flanges. Faceplate shall be 14 gage (minimum) with 15 by 15 mm holes on 5 mm 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent. Wall sleeve shall be 14 gage (minimum).

] 2.7.7 Grilles

Construct and finish as specified above for registers, except that volume dampers shall be omitted.

2.8 TROFFERS

UL Classified and UL labeled. Factory-fabricated and constructed of [steel] [or] [aluminum] and accessible for adjustment without requiring the removal of troffer components or ceiling panels. Return and supply air handling sections shall be interchangeable, except that distribution plenums are not required for return sections discharging into the ceiling plenums. Appearance of return and supply troffers shall be identical when viewed from below ceiling. When returning air to the ceiling plenum, or when not connected to supply air, the troffer shall have a maximum sound transmission class rating of 40. Equip troffers with collars at least 50 mm 2 inches long for connection to ductwork.

2.8.1 Air Seal

Resilient plastic self-adhering pressure sensitive seal between the diffuser and the frame of lighting fixtures.

2.8.2 Interior Dampers or Deflectors Finish

Black paint or anodized.

2.8.3 Lighting Fixture Characteristics

[As indicated] [and] [as specified in Division 16, Electrical].

2.9 DUCT SLEEVES, PREPARED OPENINGS, AND CLOSURE COLLARS

2.9.1 Duct Sleeves

NOTE: Where sleeves are installed in the bearing walls, the designer must provide design details in drawings of the structural steel sleeves. Consult with structural engineers for the design details.

Fabricate from minimum 20 gage [galvanized steel] [aluminum]. Where sleeves are installed in bearing walls, provide structural steel sleeves as indicated. Size sleeves to provide 25 mm one inch clearance between duct and sleeve or between insulation and sleeve for insulated ducts.

2.9.2 Prepared Openings

Provide 25 mm one inch clearance between the duct and the sleeve, or 25 mm one inch clearance between insulation and sleeve for insulated ducts except at grilles, registers, and diffusers.

2.9.3 Packing

ASTM C 553, Type 1, Class B-2, mineral fiber.

2.9.4 Closure Collars

100 mm Four inches wide minimum, fabricated from minimum 20 gage [galvanized steel] [aluminum].

[2.9.5 Security Bars

NOTE: Use this paragraph for brig facilities only.

Security bars shall be as detailed.

]2.10 DEFLECTORS

Factory-fabricated and factory- or field-assembled units consisting of curved turning vanes [or scoop type extractors] for uniform air distribution and change of direction with minimum turbulence and pressure loss. Provide curved vanes for square elbows. [For round ducts taking off from rectangular ducts, provide factory fabricated, galvanized sheet metal, spin-in fittings. These fittings shall have scoop extractors, butterfly dampers, and locking quadrant operators.]

2.11 ACCESS DOORS

Door shall be rigid and airtight with neoprene gaskets and two or more [chrome-plated [with copper or nickel base]] [enamel [painted] [galvanized]] steel hinges and quick fastening locking devices. Provide doors as large as practical. Mount doors, if possible, so that air pressure holds them closed. As an alternative, removable access doors may be used. These access doors shall be constructed from stamped sheet metal and consist of an inner and outer door panel. Where insulated doors are needed, the inner door shall consist of two panels spot-welded together which totally encapsulate fiberglass insulation. The inner and outer doors shall be joined by bolts and threaded handles in such a configuration that the panels can be drawn together to secure the door to the duct in a sandwich fashion. The handles shall be high impact plastic with threaded metal inserts. Conical springs shall be used between the door panels to facilitate installation and removal of the door. Neoprene gasket shall be used around the outside edge of the inner or outer panel, but not both, to seal the door. This type of door is approved for use on rectangular, round and flat-oval ductwork.

2.12 DAMPERS AND LOUVERS

NOTE: The design should indicate the type of dampers to be provided on the equipment schedules. Dampers must be provided on every take-off for balancing purposes. Opposed blade dampers may be required in some instances to ensure proper air mixing, but not for all customers.

Construct dampers and louvers with galvanized sheet metal two gages heavier than ducts in which installed. Except as modified herein, the construction shall be of aluminum or galvanized steel with interlocking edges and maximum 250 mm 10 inch blade width. [Dampers shall be opposed-blade type [where indicated]. Damper blades shall be connected to the damper frame with a non-metallic anti-friction bushing. The blades shall be connected to the frame with a galvanized, zinc coated steel anti-friction bearing pin. The pin shall consist of a single or double row sealed, stainless steel, maintenance free, roller or ball bearing, lubricated for life with a full stroke test of 200,000 or more strokes in accordance with UL 555S. The

bearing shall be pressed onto a steel shaft via a knurled stud. A slotted dowel pin is then inserted thru a hole connecting the two pins.]

2.12.1 Backdraft Dampers (Gravity Dampers or Shutters)

Factory-fabricated, with statically balanced blades that open automatically when the fan starts and close by gravity when the fan stops. Provide the edges of blades with felt or rubber strips to prevent rattling.

2.12.2 Manual Volume Dampers

Balancing, factory-fabricated type. Equip dampers with accessible mechanism such as quadrant operators or 5 mm 3/16 inch rods brought through the side of ducts with locking setscrew and bushing. Where quadrant operators are furnished, provide chrome plated or enamel painted type with exposed edges rounded.

2.12.3 Fire Dampers

Provide in accordance with UL 555.

2.12.4 Automatic Smoke-Fire Dampers

NOTE: For smoke-fire dampers, use UL 555S Class
III, unless the particular building and application
such as hospital dictates the use of UL 555S Class
II instead.

Multiple blade type, 82 degrees C 180 degrees F fusible fire damper link; smoke damper assembly to include pneumatically powered operator. UL 555 as a 1 1/2 hour rated fire damper; further qualified under UL 555S as a leakage rated damper. Leakage rating under UL 555S shall be no higher than Class [II] [or] [III] at an elevated temperature Category B (121 degrees C 250 degrees F for 30 minutes). Pressure drop in the damper open position shall not exceed 25 Pa 0.1 inch w.g. with average duct velocities of 13 meters per second 2500 fpm.

2.12.5 Automatic Smoke Dampers

UL listed multiple blade type, supplied by smoke damper manufacturer, with pneumatic damper operator as part of assembly. Qualified under UL 555S with a leakage rating no higher than Class [II] [or] [III] at an elevated temperature category B (121 degrees C 250 degrees F for 30 minutes). Pressure drop in the damper open position shall not exceed 25 Pa 0.1 inch w.g. with average duct velocities of 13 meters per second 2500 fpm.

2.12.6 Automatic Dampers

NOTE: Allow maximum 12 liters per second 25 cfm
leakage. For particular building and application,
such as hospital, 5 liter per second 10 cfm leakage
may be allowed.

[Section 15901N SPACE TEMPERATURE CONTROL SYSTEMS.] [Section 15910N DIRECT DIGITAL CONTROL SYSTEMS.] Maximum leakage shall not exceed [50] [130]

liter per second per square meter [10] [25] cfm per square foot of damper face area at 500 Pa 2 inch w.g. pressure difference.

2.12.7 Louvers

[Manual] [Fixed] type. Fold or bead the edges of louver blades to exclude driving rain. [Louvers blades shall be oriented to minimize the entrainment of rainwater.] Make louver frames of [16] [18] gage [galvanized steel] [or] [aluminum]. Provide bird (insect) screen constructed of the same type metal as the louvers.

2.12.7.1 Bird Screens

ASTM E 437, general industrial-use wire cloth, Grade C, medium light or heavier, nominal 2 mesh 1.60 mm 0.063 inch wire diameter, [aluminum] [or] [galvanized steel] bird screens. Provide removable insect screens of grooved type, with vinyl or neoprene spline insert for securing screen cloth.

2.12.7.2 Louvered Penthouse

Low-silhouette, curb-mounted, dome-type roof [intake] [exhaust] unit equipped with waterproof top and rainproof louvers around the sides. Provide a removable roof constructed of not less than 2 mm 0.081 inch thick [aluminum] [or] [galvanized] steel sheet insulated with 25 mm one inch thick glass fiber with vapor barrier attached to underside of roof. Internally brace the unit with not less than 50 by 50 by 3 mm 2 by 2 by 1/8 inch aluminum or galvanized steel angles. Provide curb tie-downs and bird screens. The entire assembly shall have been factory tested to withstand a 200 kilometer per hour 125 mph wind force. Provide [aluminum] [or] [stainless steel] bolts or screws in the assembly.

PART 3 EXECUTION

3.1 INSTALLATION

Except as specified or indicated otherwise, conform to NFPA 90A, SMACNA HVAC Duct Const Stds [and SMACNA FGDCS]. Provide mounting and supporting of ductwork and accessories including, but not limited to, structural supports, hangers, vibration isolators, stands, clamps and brackets, access doors, and dampers. Provide electrical isolation between dissimilar metals. Electrical isolation may be fluorinated elastomers or sponge-rubber gaskets. Install ductwork accessories as indicated and as recommended by manufacturer's printed instruction. Allow clearance for inspection, repair, replacement, and service. Louvers in accordance with AMCA 501.

3.1.1 Ductwork

Air distribution systems shall operate with no chatter or vibration.

3.1.1.1 Field Changes to Ductwork

Those required to suit the sizes of factory-fabricated equipment actually furnished, shall be designed to minimize expansion and contraction. Use gradual transitions in field changes as well as modifications to connecting ducts. [Provide jumper ducts for discharging air into duct junctions as indicated.]

3.1.1.2 Dampers

When installed on ducts to be thermally insulated, equip each damper operator with stand-off mounting brackets, bases, or adapters to provide clearance between the duct and operator not less than the thickness of insulation. Stand-off mounting items shall be integral with the operator or standard accessory of damper manufacturer.

3.1.1.3 Deflectors

Provide in square elbows, duct-mounted supply outlets, take-off or extension collars to supply outlets, and tap-in branch-off connections. Adjust supply outlets to provide air volume and distribution as [indicated or] specified.

3.1.1.4 Fire Dampers

Install in accordance with manufacturer's instructions for condition of UL 555 and NFPA 90A. Locate as indicated and provide surface penetration sleeves in accordance with approved detail drawings.

3.1.1.5 Access Doors

Provide for automatic dampers, volume dampers, fire dampers, coils, thermostats, temperature controllers, valves, filters, humidifiers and other concealed apparatus requiring service and inspection in the duct systems.

3.1.1.6 Duct Sleeves, Prepared Openings, and Closure Collars

Provide for ductwork penetrations in floors, walls, and partitions through which metallic [and] [fibrous glass] ductwork passes.

- a. Duct Sleeves: Fill space between duct and sleeve or between insulation and sleeve for insulated ducts with mineral fiber, except at grilles, registers, and diffusers.
- b. Prepared Openings: Fill space between duct and opening or between insulation and opening for insulated ducts with mineral fiber, except at grilles, registers, and diffusers.
- c. Closure Collars: Fit collars snugly around ducts or insulation. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vapor barrier. Provide nails with maximum 150 mm 6 inch centers on collars.

[3.1.1.7 Fibrous Glass Duct

Install in accordance with SMACNA FGDCS, the manufacturer's printed instructions, and UL 181. In addition to manufacturer's approved method, seal joints with fibrous glass fabric and mastic. Fibrous glass ductwork will not be allowed for the following:

- a. Square and rectangular ductwork operating over 500 Pa 2 inches water gage static pressure or 10 meter per second2000 feet per minute velocity;
- b. Exposed ductwork;

- c. Ductwork within mechanical equipment rooms;
- d. Outdoor ductwork;
- e. Ductwork within 1.50 meter 5 feet of heating or cooling coils;
- f. Vertical risers more than two floors;
- g. Kitchen or exhaust ductwork; and
- h. Ductwork in concrete or buried below grade.

]3.1.1.8 Packing

Pack spaces between sleeve or opening and duct or duct insulation with mineral fiber.

[3.1.1.9 Security Bars

NOTE: Use this paragraph for brig facilities only.

Install security bars at ductwork penetrations of roof and at ductwork penetrations of security walls and floors where duct height or width exceeds 150 mm 6 inches.

]3.1.2 Duct Hangers and Supports

NOTE: Delete the sentence for seismic restraints if the project specifications include Section 15070, "Mechanical Sound, Vibration, and Seismic Control." The designer must provide typical seismic restraint details on drawings.

SMACNA HVAC Duct Const Stds, Section 4. [Provide seismic restraint complying with SMACNA Seismic Restraint Mnl.] Attach supports only to structural framing members and concrete slabs. Do not anchor supports to metal decking unless a means is provided and approved for preventing the anchors from puncturing the metal decking. Where supports are required between structural framing member, provide suitable intermediate metal framing. [Provide retainer clips where C clamps are used.]

3.1.2.1 Flexible Ducts

Support ducts by hangers every one meter 3 feet, unless supported by ceiling construction. Stretch flexible air ducts to smooth out corrugations and long radius elbows. Provide minimum length to make connections.

3.1.2.2 Flexible Connectors

Provide flexible connectors between fans and ducts or casings and where ducts are of dissimilar metals [as indicated]. For round ducts, securely fasten flexible connectors by zinc-coated steel clinch-type draw-bands. For rectangular ducts, lock flexible connectors to metal collars.

3.1.3 Inspection Plates and Test Holes

Provide, where required, in ductwork or casings for all balance measurements. If possible, test holes should be located at least 7.5 times diameters downstream from a disturbance. Extend cap through insulation.

3.1.4 Acoustical Duct Lining

NOTE: Do not use insulation liners for ductwork at infectious areas in hospitals, such as operational suites, nurseries, pathological facilities, intensive care units, and surgical wards; use factory prefabricated sound attenuators instead. For brig facilities, fibrous glass ductwork should not be used in inmate housing area, areas accessible to inmates, nor areas with concrete, gypsum board, or plaster ceilings. Do not use fibrous glass ducts within 300 mm 12 inches of electric or fuel fired heaters.

Apply lining in cut-to-size pieces attached to interior of ducts with fire-resistant adhesive. Top and bottom pieces shall lap the side pieces. Secure pieces together with welded pins or clips. Do not distort ducts, burn through or mar the finish surface of ducts. Pins and washers shall be flush with the surface of duct liners. Seal breaks and punctures of duct-liner coating with fire-resistant adhesive. Coat exposed edges of the liner at duct ends and other joints where lining will be subject to erosion with a heavy brush coat of fire-resistant adhesive, to prevent delamination of glass fibers.

3.1.5 Sound Attenuators

Provide sound attenuators in the discharge duct of each high-pressure fan [operating at a pressure above 1000 Pa 4 inch water gage] [and] [as indicated]. For each system, provide sound attenuators to ensure that the combination of air system equipment and sound attenuation comply with the designed sound levels.

3.1.6 Flashing

[Section 07600 FLASHING AND SHEET METAL.] [Provide waterproof flashing where ducts pass through exterior walls and roofs.]

3.1.7 Cleaning of Ducts

Remove all debris and dirt from ducts and wipe clean. Before installing air outlets, force air through entire system at maximum attainable velocity to remove accumulated dust. Provide temporary air filters to protect ductwork which may be harmed by excessive dirt. For large systems, clean duct with high power vacuum machines.

[3.1.8 Security Grilles, Registers, and Diffusers

[a. Security grilles and registers with back mounting flange shall be secured to ductwork as indicated.]

[b. Security grilles without back mounting flange shall be secured to

wall or ceiling with vandal-resistant screws.]

[c. Security ceiling diffusers shall be secured to ceiling with vandal-resistant screws.]

]3.2 FIELD QUALITY CONTROL

Administer and direct tests. Furnish instruments, equipment, connecting devices, and personnel for the tests. Notify Contracting Officer [_____] days before inspection or testing is scheduled. Correct defects in work. Repeat tests until work is in compliance.

3.2.1 Duct Air Leakage Testing

Requirements for duct air leakage testing is indicated and specified in Section 15950N HVAC TESTING/ADJUSTING/BALANCING.

3.3 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurements commonly agreed on by the manufacturers or other parties. The inch-pound and metric measurements shown are as follows:

| <u>Products</u> | <u>Inch-Pound</u> | <u>Metric</u> |
|------------------------|---------------------------|-------------------|
| a. Ducts | | |
| Pressure Classes | = 3 inches of water | = 750 Pa |
| | = 4 to 10 inches of water | = 1000 to 2500 Pa |
| b. Duct Lining | | |
| Thickness | = one inch | = 25 mm |
| c. Fibrous Glass Ducts | | |
| Minimum Thickness | = one inch | = 25 mm |
| d. Smoke Damper | | |
| Operating Temperature | = 180 degrees F | = 82 degrees C |

-- End of Section --