SECTION 23 31 13
AIR DISTRIBUTION SYSTEM (Revised AD-8)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. High and low pressure ductwork, fittings and accessories.
   2. Manual dampers.
   3. Fire and smoke dampers.
   4. Backdraft and barametric dampers.
   5. Fireproof duct covering.
   6. Diffusers, registers and grilles.
   7. Sound attenuators.

AD-8: Section 23 31 13: Revise paragraph 1.1.A.8.
   8. Louver blank-off plates by Division 08.
   9. Duct access doors.
   10. Control dampers less actuators:
      a. Actuators for control dampers: See Section 25 50 00.

B. Work installed but not furnished:
   1. Automatic dampers: Furnished under Section 25 50 00.
   2. Airflow measuring stations: Furnished under Section 25 50 00.

C. Definitions:
   1. Low and high pressure ductwork: See Part 2.2 of this section.
   2. Gage:
      a. Steel sheet and wire: U S Standard Gage.
      b. Aluminum sheet: Browne & Sharpe Gage.
      c. Steel wire: Washburn and Moen Gage.
   3. Concealed insulated surfaces: Piping, ductwork and equipment in walls, partitions, floors, pipe chases, pipe shafts, duct shafts and above suspended ceilings.
   4. Exposed insulated surfaces: Piping, ductwork and equipment located in mechanical rooms, tunnels and rooms without suspended ceilings.

D. Location of diffusers, registers and grilles are indicated on Architectural reflected ceiling plans.

E. Drawings indicate tentative arrangement of partitions, diffusers and lights:
   1. Final location of diffusers, registers and grilles: Architectural reflected ceiling plans.

F. Control dampers installed in air handling units: delivered to air handling unit manufacturer and factory mounted in unit. Actuators shall be field mounted under Section 25 50 00.

1.2 QUALITY ASSURANCE

A. Design and installation standards:
   1. ASHRAE Handbook - HVAC Systems and Equipment: Current chapter on duct construction.
   2. ADC Standard 1062: GRD-84, Test Code for Grilles, Registers and Diffusers.
   3. ADC Test Code FD 72-R1, Flexible Air Duct Test Code.
   4. AMCA Standard 210, Test Code for Air Moving Devices.
   5. ASHRAE Standard 70-72, Method of Testing for Rating the air flow performance of outlets and inlets.
   6. NFPA-90A, Standard for the Installation of Air Conditioning and Ventilating Systems, current edition.

7. SMACNA HVAC Duct Construction Standard - Metal and Flexible, Current Edition.

B. Fire and smoke rating test standards: ASTM-E84, NFPA-255 and ANSI/UL-723.

C. Duct sizes indicated are internal sizes.

1.3 SUBMITTALS

A. Shop drawings:
   1. Ductwork layout at 1/4 IN to 1 FT scale.

B. Product data:
   1. Ductwork and fittings, high pressure.
   2. Dampers, nonrated.
   3. Dampers, fire.
   4. Dampers, smoke.
   5. Diffusers, registers and grilles.
   6. Sound Attenuators.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Test reports.

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable manufacturers:
   1. Flat oval and round spiral ductwork, high pressure:
      a. Base:
         1) United McGill Airflow Corporation.
      b. Optional:
         1) Semco Incorporated.
         2) Sheet Metal Connectors, Inc.
         3) Eastern Sheet Metal, Inc.
   2. Factory fabricated duct connection systems:
      a. Base:
         1) Ductmate Industries.
      b. Optional:
         1) Nexus.
         2) Ward Industries, Inc.
   3. Sealants:
      a. Base:
         1) Hardcast.
      b. Optional:
         1) Hardcast.
         2) United McGill Airflow Corporation.
         3) Foster (Division of HB Fuller).
   4. Turning vanes:
      a. Base:
         1) Aerodyne Controls.
      b. Optional:
         1) Airsan.
         2) Tuttle & Bailey.
         3) Titus.
         4) VentProducts.
   5. Flexible fan connections:
      a. Base:

1) Ventfabrics.

b. Optional:

1) Duro-Dyne.
2) Elgin.

6. Flexible duct, preinsulated:
   a. Base:
      1) Atco.
   b. Optional:
      1) Flexible Technologies, Thermaflex.
      2) Hart and Cooley.
7. Flexible ducts, uninsulated:
   a. Base:
      1) United McGill Corp.
   b. Optional:
      1) ATCO Rubber Products, Inc.
      2) Or approved equal.
8. Fireproof duct covering:
   a. Base:
      1) Pabco.
      2) Thermal Ceramics.
   b. Optional:
      1) Flexible Technologies, Thermaflex.
      2) 3M.
9. Access Doors, low and high pressure:
   a. Base:
      1) Ductmate.
   b. Optional:
      1) Ward Industries.
      2) United McGill Airflow Corporation.
10. Dampers(manual, backdraft, barametric):
    a. Base:
       1) Ruskin Manufacturing.
    b. Optional:
       1) Arrow.
       2) Louvers and Dampers, Inc.
       3) American Warming & Ventilating.
       4) Air Balance.
       5) Cesco Products.
11. Fire and smoke dampers:
    a. Base:
       1) Ruskin Manufacturing.
    b. Optional:
       1) Air Balance.
       2) Greenheck.
       3) Nailor-Hart Industries, Inc.
       4) Prefco Products.
       5) Safe-Air of Illinois.
       6) CESCO products.
12. Diffusers, registers and grilles:
    a. Base:
       1) Titus.
    b. Optional:
       1) Carnes.
       2) Anemostat Air Products.
       3) Tuttle & Bailey.
       4) Krueger.

5) Price.

13. Sound Attenuators:
    a. Base:
        1) Vibro-Acoustics.
    b. Optional:
        1) AeroSonics.
        2) Dynasonics.
        3) Rink Sound Control.
        4) Semco Incorporated.
        5) TranSonics.
        6) United McGill Airflow Corporation.
14. Pressure relief doors:
    a. Base:
        1) Ruskin.
    b. Optional:
        1) Kees.

B. Sheet metal:
    1. Galvanized steel (G90): ASTM-A653/A653M.
    2. Stainless steel: ASTM-A167.

C. Duct sealer: NFPA rating of "Non-Combustible":
    1. Flame spread rating: 25 or lower, in dry condition.
    2. Smoke developed rating: 50 or lower, in dry condition.
    3. Resistant to water and water vapors.
    4. Pressure rupture rating: 16 IN WG , minimum.
    5. Durkee-Atwood Permatite Class I Duct Sealer; Hardcast Iron Grip 601 and Duct Seal 321; or United McGill Sheet Metal Uni-Mastic 181 Duct Sealer and United Duct Sealer.

D. Solder: ASTM-B23, Grade-50B.

E. Duct sealing tape: NFPA rating of "Non-Combustible":
    1. Flame spread rating: 25 or lower, in dry condition.
    2. Smoke developed rating: 50 or lower, in dry condition.
    3. Adhesive: Specifically compounded for maximum adhesion to galvanized and stainless steel.
    4. Durkee-Atwood Permatite Class I Insta-Seal; Hardcast Aluma-Grip 701 and Flange Grip 1902; or United McGill Sheet Metal Uni-Cast tape.

F. RTV foam: UL listed room temperature vulcanized silicone rubber foam.

2.2 DUCTWORK

A. Ductwork - general:
    1. Maintain full areas and suitable shapes at every point.
    2. Shapes may be changed to fit unusual space conditions:
        a. Cross sectional area to be maintained.
        b. Modifications increasing system pressure drop require BNL approval.
        c. Modifications increasing aspect ratio beyond 5:1 require BNL approval.
    3. Provide necessary transitions and offsets to complete systems.
    4. All systems shall be constructed of G90 galvanized steel, except as follows:
        a. Laboratory and cleanroom exhaust branch ducts from fume hoods to horizontal duct mains and canopy hoods: 316 stainless steel.

B. Ductwork, low pressure, sheet metal:
    1. Construct in accordance with SMACNA HVAC Duct Construction Standard as follows:
        a. Rectangular duct: Table 1-6, 3 IN WG static pressure, positive or negative.
        b. Rectangular duct: Table 1-7, 4 IN WG static pressure, positive or negative.
        c. Round duct: Table 3-2A, 4 IN WG static pressure, positive or negative.

2. Low pressure ductwork, 3 IN WG static pressure includes:
    a. Outside air ductwork.
    b. Return air ductwork, unless otherwise noted.
    c. All general exhaust ductwork.
    d. All supply ductwork serving FCU'S.
3. Low pressure ductwork, 4 IN WG static pressure includes:
    a. Relief ductwork.
    b. All supply ductwork downstream of air terminal units.
4. Transverse joints, rectangular:
    a. Ducts with longest side 36 IN and longer:
        1) Use factory fabricated flanged duct connection systems (e.g. Ductmate 35/25 slide on systems).
        2) Non-proprietary SMACNA defined T-22 or T-24 flanged connections
        3) Seal transverse flanged duct connections with pressure sensitive, high density, closed cell, neoprene or polyurethane tape gasket.
    b. Ducts with longest side shorter than 35 IN:
        1) Flanged duct connection systems as defined above are optional.
        2) Refer to SMACNA HVAC Duct Construction Standard for proper duct construction.
5. Longitudinal seam: Use Pittsburgh lock seam only.
6. Seal low pressure ducts to Seal Class A requirements.
7. Runouts to diffusers, register and grilles: Insulated flexible ducts may be used:
    a. Exception: Flexible ducts may not pass through smoke or fire rated walls, floors or ceilings.
    b. Flexible duct length: 6 FT maximum.
    c. Minimum turning radius:
        1) As recommended by manufacturer.
        2) Do not kink, bend or restrict free area of duct as to generate additional pressure drop or noise.

C. Ductwork located outside, exposed to weather:
1. Construct using flanged duct connection systems.
2. Seal flanged ends with pressure sensitive, high density, closed cell, neoprene or polyurethane tape gasket.
3. Use continuous cleat seals on top joints of ducts.

D. Ductwork, high pressure:
1. Construct in accordance with SMACNA HVAC Duct Construction Standard as follows:
    a. Rectangular duct: Table 1-8, 6 IN WG static pressure, positive or negative.
    b. Round duct: Table 3-2A, 10 IN WG static pressure.
2. High pressure ductwork includes:
    a. Supply ductwork serving AHU from air handling unit discharge to connection with air valves/terminal units.
    b. All exhaust ductwork serving laboratories and clean rooms.
3. Runouts to air terminal units: Rigid or flexible ductwork.
    a. Exceptions:
        1) Flexible ducts may not pass through smoke or fire rated walls, floors or ceilings.
        2) Flexible ducts shall not be used for connections to air terminal units for exhaust or return systems.
    b. Flexible duct length: 4 FT minimum, 6 FT maximum.
    c. Minimum turning radius:
        1) As recommended by manufacturer. Do not kink, bend or restrict free area of duct as to generate additional pressure drop or noise.
        2) Ninety degree bends are not allowed.
4. Seal high pressure duct to seal Class A requirements.

E. Duct hangers and supports: In accordance with following:
   1. High and low pressure ductwork (sheet metal): SMACNA HVAC Duct Construction Standard, Section IV.

F. Duct fittings and joints on low pressure systems:
   1. Radius elbows without vanes: Radius ratio (R/W) of 1.5 and greater.
   2. Radius elbows with vanes: Radius ratio (R/W) less than 1.5; use where space limitations occur:
      a. R/W = 0.75 to 1.0: Provide 3 vanes in elbow.
      b. R/W = 1.0 to 1.25: Provide 2 vanes in elbow.
      c. R/W = 1.25 to 1.5: Provide 1 vane in elbow.
      d. Provide vane spacing per Figure 2-3, SMACNA HVAC Duct Construction Standards.
   3. Where square elbows are indicated or required, provide with turning vanes.
   4. Connections to diffusers, grilles and registers: Fitted securely to necks or collars provided behind diffuser, grille, or register face area.
   5. Branch connections:
      a. Round: Factory built short cone or bellmouth type. Air scoops are not acceptable.
      b. Rectangular: 45 degree entry type or radius elbow.
   6. Provide necessary transition pieces and duct collars to make connections to ductwork from neck sizes scheduled or indicated on drawings.
   7. Where building walls, floor and ceilings form portions of duct or plenum, provide gasketed angles or channels at junction points, securely bolted to building structure.

G. Duct fittings and joints on high pressure systems:
   1. Elbows 3-8 IN diameter: Die stamped, for minimum air friction loss, with continuous corrosion resistance welds.
   2. Elbows over 8 IN diameter: Welded segment type, not less than 5 pieces for 90 degree elbows, and not less than 3 pieces for 45 degree elbows, using corrosion resistant welds.
   3. Tees: "Low loss, short cone type", unless specifically detailed otherwise for space limitations.
   4. "Y's" 45 degree type. 60 degree type may be used if space conditions dictate.
   5. Install "Y's" as indicated.
   6. Where tees are indicated, "Y's" may be substituted if space is available.
   7. "Y's": Straight sided type (no cone).
   8. Takeoffs from air handling unit plenums: Standard Bellmouth fittings:
      a. Construct in accordance with SMACNA HVAC Duct Construction Standards.
   9. "Y" takeoffs from horizontal ceiling mounted ducts to serve boxes: May be straight sided, shop fabricated type by accurately cutting and welding "Y's" into spiral ducts without use of fittings.

H. Turning vanes: For square elbows:
   1. Velocities up to 2500 FPM: Single vane, runner Type 2, 2 IN vane radius and 1.5 IN vane spacing, minimum 24 GA:
      a. For widths over 36 IN install vanes in 2 or more sections or use tie rods to limit unbraced vane length.
   2. Where inlet and outlet dimensions of elbows are not equal, set 2 or more sections at 45 degrees angle to give optimum turning.

I. Partitions and blank-off plates:
   1. Where used as part of an air handling unit, construct of 14 GA sheet metal with 1-1/2 IN standing seams.
   2. Partitions 8 FT long or less: Provide additional bracing of 1-1/2 x 1/4 IN angles spaced 2 FT on center.
   3. Partitions over 8 FT long: Provide additional bracing of 2 x 1/4 IN angles spaced 2 FT on center.

J. Flexible fan and duct connections:
   1. Material: Neoprene double coated closely woven glass fabric flexible connections.

2. Fasten fabric to sheet metal duct work and to fan collar extension with 3/16 IN rivets spaced not more than 5 IN OC.
3. Locate in inlet and outlet of fans, as close to fan as possible.
4. Provide at ducts crossing building expansion joints and as indicated on drawings.
5. Connections shall not be under tension.
6. Provide minimum separation distance of 1 IN across the connection.

K. Flexible ducts, preinsulated:
1. Low pressure construction:
a. Liner: Steel wire helix encapsulated within a double lamination of polyester.
b. Insulation: 1 IN x 3/4LB/CF fiberglass insulation, minimum resistance of R-4.2.
c. Insulation: 1 IN x 3/4 LB/CF fiberglass insulation, minimum resistance of R-6. Jacket: Bi-directional metalized polyester.
2. High pressure supply construction:
a. Insulation: 1 IN x 3/4 LB/CF fiberglass insulation, minimum resistance of R-4.2.
b. Jacket: Bi-directional metalized polyester.

L. Flexible ducts, uninsulated:
1. Provide for all connections to HEPA filter diffusers and where indicated.
2. Medium pressure construction:
a. Heavy gauge corrugated aluminum.
b. Aluminized mylar, wire reinforced and fabric type not permitted.
3. Rated working pressure:
a. Medium pressure duct: Positive 8 IN minimum.
4. Fire resistant, self extinguishing, UL Standard 181, Class 1 with flame spread of 25 or less and smoke development not to exceed 50.
5. Medium pressure connections:
a. Secure duct to collar or sleeve with duct sealer and number and type of fasteners as required in SMACNA HVAC Duct Construction Standards.
6. Duct sealer: E Moore Co., Tuff-bond No. 12; or Benjamin Foster No. 30-02.
7. Turn radius: Not less than R/D equal to 1.0.
8. Provide flexible duct supports in accordance with Figure 3-9 and 3-10, SMACNA HVAC Duct Construction Standards.

M. Access doors:
1. Provide at fire dampers, smoke dampers, smoke detectors, duct mounted automatic dampers, pressure and temperature sensors, air plenums behind louvers and at other locations as required. Access doors shall be positioned to permit easy visual inspection and to allow maintenance and resetting of the device served. Increase duct dimensions at devices when necessary to accommodate required access. Wherever possible, access doors shall be installed above accessible lay-in ceilings. Where access doors are installed above gypboard ceilings or within shafts, provide access panels per Section 20 05 00.
2. Low and high pressure ductwork:
a. Construction: Access doors shall be removable, double wall construction with 1 IN thick fiberglass insulation, closed cell neoprene gasket and attachment bolts, to provide an air tight seal up to static pressures of 20 IN WG.
b. Sizes shall be as follows:
1) For ducts 18 IN and under, the minimum door size shall be 10 IN X 6 IN.
2) For ducts 19 IN to 24 IN, the minimum door size shall be 16 IN X 12 IN.
3) For ducts over 24 IN the minimum door size shall be 24 IN X 18 IN.

2.3 DAMPERS

A. Dampers - general:
1. Sizes and types: As indicated.
2. Locate as indicated.
3. Factory built and assembled dampers.

B. Dampers, control:
   1. Furnish under Section 25 50 00.
   2. Install as specified in this section.

C. Dampers, manual (rectangle and square):
   1. Opposed blade type, fitted with shank bolts, marked for direction (open/closed).
   2. Provide for double socket wrenches to fit square shank and locking hex nut.
   3. Construction: Heavy black iron frames, flat or angle iron, with blades of 16 GA galvanized steel, equipped with brass pin running on stainless steel pivot for vertical axis.

D. Damper, manual (round):
   1. Butterfly type with circular blade mounted to shaft.
   2. Frame: Minimum 14 GA galvanized steel channel.
   3. Blade: Minimum 16 GA galvanized steel.
   4. Axle: 1/2 IN diameter.
   5. Bearings: Self-lubricating nylon or stainless steel sleeve.

E. Dampers, backdraft, low pressure:
   1. Counterbalanced, gravity operated.
   2. Fabricate of aluminum.
   3. Blades: Provided with common linkage rod and felt seals.

F. Dampers, barametric, low pressure:
   1. Counterbalanced, static pressure operated.
   2. Counterweight adjustable to hold damper blades closed until specified static pressure is reached.
   3. Fabricate of aluminum.
   4. Blades: Provided with common linkage rod and felt seals.

2.4 FIRE DAMPERS

A. Fire dampers - general:
   1. UL labeled, 1.5 Hour rated (unless otherwise indicated).
   2. Fire dampers shall have 165 degF fusible link.
   3. Fire dampers shall be dynamic type.
   4. Provide as indicated and as required by NFPA and local regulations.
   5. Provide with mounting angles and sleeves.
   6. For curtain-type fire dampers, blades must be out of air stream (Type B fire damper).

B. Fire dampers in low pressure ducts:
   1. Provide curtain type damper, Ruskin Model DIBD2:
      a. Rated up to 2375 FPM at 4 IN WG for vertical mounted applications.
      b. Rated up to 2520 FPM at 4 IN WG for horizontal mounted applications.

C. Fire dampers in high pressure ducts:
   1. For vertical mounted applications: curtain type damper, Ruskin Model DIBDX2:
      a. Rated up to 4550 FPM at 8 IN WG.
   2. For horizontal mounted applications: curtain type damper, Ruskin Model DIBD2:
      a. Rated up to 2520 FPM at 4 IN WG.

2.5 SMOKE DAMPERS

A. Smoke dampers - general:
   1. UL classified as a leakage rated damper for use in smoke control systems under UL555S, latest edition, and bear a UL label attesting to same.
   2. Suitable for velocity and pressure of system.
   3. Jamb seals: Stainless steel flexible metal compression type.
   4. Provide in ductwork adjacent to smoke partition (not in wall) with actuator in accessible location and visible for inspection.
   5. Actuator shall not be inside of duct.

6. Provide dampers and actuators as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and actuators as a rated assembly.
7. Frame: 16 GA galvanized steel, minimum.
8. Loss through wide open damper:
   a. Not more than 0.15 IN WG at 3000 FPM face velocity for high pressure.
   b. Not more than 0.15 IN WG at 2000 FPM face velocity for low pressure.
9. Provide factory supplied caulked sleeve.
10. Provide smoke dampers as indicated.

B. Smoke dampers, low pressure:
1. Parallel blade type with blades hinged together for operation in unison and bearings arranged for automatic operation.
2. UL555S Leakage Rating: Class I (4 CFM/ SF at 1 IN WG):
   a. Ruskin Model SD37.
3. Blades: Single or double thickness type:
   a. Single thickness type: 16 GA steel, minimum.
   b. Double thickness type: 18 GA steel.
4. Blade width: Not more than 6 IN.
5. Single blade dampers may be used for up to 8 IN wide blade, or up to 12 IN round.

C. Smoke dampers, square or rectangular, high pressure:
1. Parallel or opposed blade type with linkage for automatic operation.
2. UL555S Leakage Rating: Class I (8 CFM/ SF at 4 IN WG):
   a. Ruskin Model SD60 or SD50.
3. On round or flat oval ductwork:
   a. Provide dampers in an enclosure with round or oval connections on each side.

D. Smoke dampers, round or flat oval, high pressure:
1. Single blade type with encompassed blade edge seal.
2. UL555S Leakage Rating: Class I (8 CFM/ SF at 4 IN WG):
   a. Ruskin Model SDRS25.

E. Damper actuator (operator): Electric type, factory installed:
1. Two-position type.
2. 120 VAC.
3. Spring return fail closed.
4. UL listed at 250 degF.

2.6 COMBINATION FIRE-SMOKE DAMPERS

A. Fire-smoke dampers, combination - general:
1. UL classified as a Leakage Rated damper under UL555S, latest edition, bearing a UL label attesting to same.
2. UL555 fire rating: 1.5 Hour.
3. Suitable for velocity and pressure of system.
4. Compressible metal jamb seals.
5. Actuator installed per UL requirements, in accessible location and visible for inspection.
6. Actuator shall not be inside duct.
7. Provide dampers and actuators as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and actuators as a rated assembly.
8. Frame: 16 GA galvanized steel, minimum.
9. Loss through wide open damper based on AMCA Test Figure 5.3:
   a. 12 IN x 12 IN duct size: Not more than 1.25 IN WG at 3000 FPM face velocity.
   b. 24 IN x 24 IN duct size: Not more than 0.45 IN WG at 3000 FPM face velocity.
   c. 36 IN x 36 IN duct size: Not more than 0.3 IN WG at 3000 FPM face velocity.
10. Provide factory supplied caulked sleeve.
11. Provide fire-smoke dampers as indicated.

B. Fire-smoke dampers, combination, low pressure:
   1. Parallel blade type with blades hinged together for operation in unison and bearings arranged for automatic operation.
   2. May be used in lieu of separate fire and smoke dampers.
   3. UL555S Leakage Rating: Class I (4 CFM/SF at 1 IN WG):
      a. Ruskin FSD37.
   4. Fusible link: 165 degF melting point.

C. Fire-smoke damper, combination, high pressure:
   1. Parallel blade type.
   2. May be used in lieu of separate fire and smoke dampers.
   3. UL555S Leakage Rating: Class I (8 CFM/ SF at 4 IN WG):
      a. Ruskin Model FSD60 .
   4. Fusible link: 165 degF melting point.

D. Damper actuator (operator): Electric type, factory installed:
   1. Two-position type.
   2. 120 VAC.
   3. Spring return fail closed.
   4. UL listed at 250 degF.

2.7 DIFFUSERS, REGISTERS AND GRILLES

A. Diffusers, ceiling:
   1. Square type.
   2. Size, type and manufacturer: As scheduled.
   3. Finish of steel units: Factory applied, baked or electrocoated enamel; color as selected by Architect/Engineer or as indicated.
   4. Provide necessary screws, duct collars, transitions and air pattern deflectors.
   5. Provide opposed blade dampers where indicated.

B. Diffusers, radial throw type:
   1. Size, type and manufacturer: As scheduled.
   2. Provide with steel housing with hinged face to allow filters to be replaced from within the room without requiring access to the ceiling.
   3. Diffusers: Capable of 180 degree radial throw pattern.
   4. Provide gasket material around frame body on frame face of air seal.
   5. Finish: Baked, white epoxy finish.

C. Air grilles and registers:
   1. Size, type and manufacturer: As scheduled.
   2. Finish of steel units: Factory applied, baked or electrocoated enamel; color as selected by Architect/Engineer or as indicated.
   3. Provide necessary screws, duct collars and transitions.
   4. Provide opposed blade dampers in registers where indicated.

D. Diffusers and grilles, linear slot type:
   1. Size, type and manufacturer: As scheduled on drawings.
   2. Adjustable pattern controller (on supply units only) capable of 180 degree air pattern adjustment and volume control. All adjustments accessible from the face of the diffuser.
   3. Extruded aluminum or steel ceiling linear diffuser.

2.8 SOUND ATTENUATORS

A. Sound Attenuators:
   1. Prefabricated, straight through design.
   2. Airflow pressure drop and noise reduction (NR) values as indicated on drawings.
   3. Size and shape as indicated on drawings.
   4. Outer casing: 22 GA, minimum, galvanized steel.

5. Interior partitions or splitters: 24 GA, minimum, perforated galvanized steel.
6. Aluminum construction: At least 50 percent thicker than steel specified.
7. Use straight through air passages.
8. Use airtight construction:
    a. Make unit leakproof when subjected to differential air pressure of 8 IN WG between outside and inside.
    b. Weld lock joints or seams or fill with mastic.

B. Sound attenuators, noise reduction (NR) rating:
1. Tests made in such manner as to eliminate end reflections, beaming or directivity, flanking, standing waves, and room absorptions.
2. Test method may be either "in-duct with anechoic termination" or "reverberant rooms with tunnel between".
3. Size of units tested: Not smaller than 24 IN x 24 IN rectangular or 24 IN round outside, with full size connections.
4. Submit corroborative report of tests made in nationally recognized, qualified, independent testing laboratory approved by AMCA for airflow determinations.

C. Sound attenuators, airflow pressure drop rating:
1. Do not exceed pressure drop at specified airflow(s).
2. Base rating on results of tests made in manner to provide reliable data.
3. Basic setup: Standard code method as adopted by AMCA for testing fans.

D. Sound attenuators, acoustical fill:
1. Inert, vermin and moisture proof, inorganic glass or mineral fiber.
2. Pack behind partitions or splitters under not less than 5 percent compression to provide "spring" and avoid settling.
3. Fill containment: totally encapsulated and sealed with a polymer film. Separate fill material from perforated baffle by a non-combustible, erosion resistant, acoustical stand-off. Refer to schedule for applicability.

2.9 HEPA FILTER MODULES

A. HEPA Filter Modules:
1. Ducted filters shall be anodized extruded aluminum housing with 12" diameter duct collar connection. Furnish a baffle plate to permit uniform air distribution inside the module. The support lip shall be a continuous part of the extruded aluminum frame. HEPA filters as manufactured by American Air Filter or Camfil.
2. Filter Assembly:
    a. Factory built and assembled.
    b. Removable ceiling filter module to be replaceable from room side.
    c. Filter assembly hermetically sealed.
3. Filter:
    a. Extended surface, 99.99 percent efficient certified on 3 micron particles. Tested and constructed accordance with IES-RP-CC-001 for Type C HEPA Filters:
        1) 4 IN deep mini-pleated, American Air Filter Model TM4 disposable type. Or equal by manufacturers listed under “MATERIALS” in Part 2 of this section.
        2) Nominal resistance at rated air flow: Not greater than 0.25 IN WG at 70 f.p.m. usable face velocity.
        3) UL rated, Class 1.
        4) Provide 5% extra stock.
4. Filter module:
    a. Aluminum perimeter and internal channels with welded corners. American Air Filter Model TM4 with 14 IN inlet. Module shall be 7 IN high to house the 4 IN deep filter.
    b. Perimeter edge for gasket sealing system.
    c. Filter sizes to fit modular ceiling system as indicated herein.
    d. Module to include perforated diffusion damper, UL-900, perforated 12 IN inlet disc, Class 1 housing, filter, white filter face guard.

5. Acceptable manufacturer:
   a. Base:
      1) American Air Filter.
   b. Optional:
      1) Cambridge.
      2) Camfil Farr.

PART 3 - EXECUTION

3.1 GENERAL

A. Install and coordinate systems and components.

B. Install air flow measuring stations furnished with Section 25 50 00 in accordance with manufacturer's installation instructions and as specified.

3.2 INSTALLATION OF DUCTWORK

A. Install generally as indicated.

B. Conceal ductwork in finished spaces unless indicated otherwise.

C. Do not install ductwork in or allow to enter or pass through electrical rooms, elevator machine rooms, or spaces housing switchboards, panelboards or distribution boards, except ductwork that serves electrical rooms, elevator machine rooms, or spaces.

D. Exercise special care to provide tight fitting well fabricated, well braced ductwork systems.

E. Field assemble rectangular or round ductwork as follows:
   1. Use duct joint sealer applied slip joints.
   2. Use Ductmate Spiralmate or Ovalmate systems.
   3. Isolate dissimilar metals with elastomeric sealant tape or fiber gaskets, and gaskets and washers for bolts.
   4. Install TDC flanged duct connection systems in accordance with SMACNA construction standards.

F. In high pressure round ductwork, do not use 2 piece mitered 90 degree elbows with or without vanes.

G. Fabricate duct connections for openings, fans, and other devices.

H. Where ducts pass thru fire rated and smoke rated construction, maintain rating indicated:
   1. Where fire dampers are not used, seal around duct with firestopping.
   2. See Section 07 84 00 for materials.

I. Do not bend or otherwise restrict the free area of flexible ductwork.

J. Install air terminal units for easy access from floors and from above ceiling platforms:
   1. Obtain BNL’s approval prior to proceeding with installation of air terminal units.

3.3 INSTALLATION OF FIRE AND SMOKE DAMPERS

A. Install in accordance with manufacturer's instructions and UL requirements:
   1. See Section 07 84 00.

B. Provide typical, prototype installation to include wall mounted dampers for the different wall constructions. Obtain approval of BNL's Fire Protection Authority before proceeding with the remainder of the damper installations. Submit certificate of approval to BNL's Physical Facilities prior to installation of any other fire and smoke dampers.

3.4 PERFORMANCE TESTS

A. BNL's representative to perform random visual examination of each duct section.

B. BNL to employ the services of a qualified testing agency.

C. When testing indicates that ductwork does not meet leakage class 6 as defined in SMACNA HVAC Systems Duct Design Manual for Seal Class A, discretionary judgement by BNL and the BNL will be used to determine the extent of work rejected due to failed leak tests.

D. All work rejected must have joints disassembled and remade as required to pass leakage testing at no additional cost to BNL.

3.5 CLEANING

A. At substantial completion, clean work installed under this section. Wipe ducts clean inside.

3.6 EQUIPMENT DEMONSTRATION

A. At substantial completion, inspect and test, and operate satisfactorily, in presence of BNL and representative of BNL, operation of each piece of equipment and its accessories.

B. If inspection or test indicates defects, replace defective work or material.

C. Repeat inspections and tests until defects are eliminated.

END OF SECTION