

**SECTION 23 33 00**  
**AIR DUCT ACCESSORIES**

**PART 1 - GENERAL**

**1.1 STIPULATIONS**

- A. The specifications sections "General Conditions to the Construction Contract", "Special Conditions" and "Division 01 - General Requirements" form a part of this Section by this reference thereto, and shall have the same force and effect as if printed herewith in full.

**1.2 ADDITIONAL RELATED DOCUMENTS**

- A. Division 26 or 28 for duct-mounted smoke detectors.
- B. Related Division 23 Sections:
  - 1. "Instrumentation and Control for HVAC" for motor operated dampers.
  - 2. "Diffusers, Registers, and Grilles" for manual volume dampers that are integral to diffusers, registers, and grilles.

**1.3 SUMMARY**

- A. This Section includes the following:
  - 1. Backdraft dampers
  - 2. Manual-balancing volume control dampers
  - 3. Life-safety dampers
  - 4. Single wall turning vanes and vane rails
  - 5. General duty duct-mounted access doors
  - 6. Instrument test holes
  - 7. Flexible ducts
  - 8. Flexible connectors
  - 9. Duct accessory hardware
  - 10. Remote balancing damper operators
  - 11. Duct silencers
  - 12. Louvers
  - 13. Louver blank-off panels
  - 14. Flexible duct elbow braces

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, location, and size of each field connection. Detail the following:
  - 1. Special fittings and manual-volume-damper installations.

2. Fire-, smoke-, combination fire/smoke, and ceiling radiation damper installations, including sleeves and duct-mounted access doors and panels.
  3. Duct security bars.
  4. Louver installations. The Division 23 Contactor shall verify in the field the exact dimensions required for louvers to properly and fit in and completely fill building openings formed by the General Contractor.
- C. Product Certificates and Performance Data for Duct Silencers: Submit certified test data on dynamic insertion loss; self-noise power levels; and airflow performance data, static-pressure loss, dimensions, and weights. Ratings shall be made in accordance with ASTM Specification E-477, latest revision.
1. The aero-acoustic laboratory shall be NVLAP accredited for the ASTM E-477-13 or the ISO 7235 test standard. A copy of the accreditation certificate shall be included with the silencer submittals.

## **1.5 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved. Also include locations of remote balancing damper operators and instrument test holes for use by the Testing and Balancing Agent.

## **1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

## **1.7 QUALITY ASSURANCE**

- A. NFPA Compliance: Comply with the following NFPA standards:
1. NFPA 80 and NFPA 105 for testing and inspection of fire dampers, smoke dampers and combination fire/smoke dampers.
- B. Combustion Ratings. All duct accessory materials shall be equal to or less than the combustion ratings noted below when tested in accordance with ASTM E84, UL723 and NFPA 255.
1. Flame Spread Classification: < 25
  2. Smoke Development Rating: < 50
- C. All duct accessories shall meet or exceed the SMACNA pressure class standards for the ductwork system in which they are installed, or the specified ratings, whichever are higher.
- D. Damper pressure drop and air leakage ratings shall be based on tests and procedures performed in accordance with AMCA 500-D.
- E. Duct silencer performance ratings shall be in accordance with ASTM E477, latest revision.

## 1.8 COORDINATION

- A. Coordinate with the General Contractor the selection and installation of life safety dampers with the architectural assemblies in which they are installed, so that the damper maintains the fire and smoke resistance of the assembly per the UL listing, and the damper can be installed in full accordance with its own UL listing.

## PART 2 - PRODUCTS

### 2.1 DAMPERS

- A. General: The following general provisions apply to all dampers, unless noted otherwise:
  - 1. Dampers shall be rated for no less than 2,000 feet per minute (fpm).
  - 2. Dampers shall be pressure rated for no less than the system pressure to which they are connected, or the specified rating herein, whichever is higher.
  - 3. Nominal damper dimensions shall match the connecting ductwork size indicated.
  - 4. Contractor shop-fabricated dampers are not acceptable. Dampers shall be factory fabricated by one of the manufacturers listed herein.
  - 5. Dampers shall have flanged or slip end connections. 'In-duct' type installations are not acceptable.
- B. Backdraft Dampers:
  - 1. Standard-Construction Backdraft / Barometric Relief Dampers: Factory made of minimum .050" extruded 6063-T5 aluminum blades supported on aluminum, stainless steel, or zinc plated steel rods (axles), in nylon or Celcon® bearings, set in minimum .060" 6065-T5 extruded aluminum frame. Blades shall be fitted with mechanically fastened extruded silicone or vinyl seals on contact edges to prevent noise. Aluminum and zinc-plated steel linkage hardware shall installed in the side of the frame. Damper assembly shall be provided with an adjustable counter-balance device adjusted to assist closing or opening as indicated or required by the application. Counterweight shall permit the start of opening with as little as 0.01" w.g. differential pressure.
    - a. Fans and gravity ventilators equipped with backdraft dampers shall be furnished with dampers conforming to the requirements of this specification, and shall be furnished with dampers no smaller than the full size of the connecting collar.
    - b. Dampers shall be suitable for up to 3" w.g. system pressure and 2,000 fpm velocity. Provide multiple dampers mulled together to form backdraft dampers with blade widths accommodating these pressure and velocity rating requirements.
    - c. Static pressure drop at 1,500 fpm face velocity shall not exceed 0.25" w.g. when tested in accordance with AMCA 500D in the 24"x24" size.
    - d. Dampers shall not have a leakage rate exceeding 10 cfm/sq.ft. at 1.0" w.g. differential pressure when tested in accordance with AMCA 500D in the 24"x24" size.
    - e. Damper shall be TAMCO Series '7000CW / 7000WT', or approved equal.
- C. Standard-Construction Rectangular (Manual Balancing) Volume Control Dampers:
  - 1. Volume control dampers shall be of the factory fabricated opposed blade, multi-blade type, controlled from a single point using linkages and a manual, locking quadrant.. On insulated ducts, the quadrant shall have a minimum 2" standoff bracket (or as otherwise required to accommodate the specified insulation thickness and permit damper operation

without insulation damage). Dampers shall be mounted in minimum 16 gauge roll formed galvanized steel channel frames with corner reinforcements. Blades shall be minimum 18 gauge galvanized roll-formed steel with a triple-V profile. Damper axles shall be 1/2" diameter plated steel, square or hex type, and the bearings shall be bronze or stainless steel oilite. Adjusting devices shall have locking mechanisms and shall be accessible. Damper shall be suitable for up to 2,000 fpm and 3.0" w.g. system pressure. Quadrants shall be oriented so that when the handle is parallel to the direction of airflow, the damper shall be fully open.

- a. At the Contractor's option, for rectangular dampers no taller than 12" on systems specified with a pressure rating of 2" w.g. or less, and exposed to velocity no greater than 2,000 fpm, a single blade type damper complying with all other provisions indicated above may be provided, however the bearings (including the end bearing) are permitted to be synthetic, and the frame and blades may be as thin as 18 and 20 gauge, respectively.
2. Aluminum Rectangular Volume Control Dampers: Shall be as generally specified above for multi-blade dampers, but shall have type aluminum blades, frames, and axles. Blades and frames on dampers shall be minimum .080" thick.
  - a. Arrow Model '507', or approved equal.

D. Standard-Construction Round (Manual Balancing) Volume Control Dampers:

1. Factory fabricated, single blade, center pivoted, constructed of galvanized sheet steel, minimum 22 gauge blade and frame for diameters up to 12", and minimum 20 gauge blade and frame for diameters larger than 12". Damper shall be controlled from a single point with a manual locking quadrant, and the opposite end shall be fitted with an end bearing support (i.e. no cantilevered dampers). On insulated ducts, the quadrant shall have a minimum 2" standoff bracket (or as otherwise required to accommodate the specified insulation thickness and permit damper operation without insulation damage). Axle shall be 1/4" square or hex shaped, plated steel, and the bearings shall be synthetic or brass. Damper shall be suitable for up to 2,000 fpm and 2.0" w.g. system pressure. Quadrants shall be oriented so that when the handle is parallel to the direction of airflow, the damper shall be fully open.
  - a. For systems with a specified pressure class above 2" w.g. and up to 3" w.g., the Contractor shall provide one of the following:
    - 1) Provide a square, multi-blade damper as specified above with a pair of square to round transitions. The height and width of the square damper shall match the round duct diameter indicated.
    - 2) Provide a round damper with a pressure rating meeting or exceeding the specified pressure class of the connected duct system.
2. Aluminum Round Volume Control Dampers: Shall be as generally specified above, but shall have type aluminum blades, frames, and axles. Blades and frames on round dampers shall be minimum .080" thick.

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

1. Backdraft Dampers:
  - a. Air Balance Inc.

- b. American Warming & Ventilating (AWV)
  - c. Arrow United Industries, Inc.
  - d. Greenheck Fan Corp.
  - e. Ruskin Company
  - f. Pottorff
  - g. Cesco Products, Div. of Mestek Inc.
  - h. TAMCO, T.A. Morrison and Co. Inc.
  - i. Or equal as approved by the Professional.
2. Manual Balancing Volume Control Dampers:
- a. Air Balance Inc.
  - b. American Warming & Ventilating (AWV)
  - c. Louvers and Dampers, Inc.
  - d. NCA Manufacturing.
  - e. United McGill Corp.
  - f. Ruskin Company
  - g. Pottorff
  - h. Cesco Products, Div. of Mestek Inc.
  - i. TAMCO, T.A. Morrison and Co. Inc.
  - j. Or equal as approved by the Professional.

## 2.2 LIFE SAFETY DAMPERS

### A. Fire Dampers:

1. General: Provide dynamically rated fire dampers with fusible links, where required by the 2018 International Building Code, and where indicated on the Drawings. Fire dampers shall be rated for 1-1/2 hours or 3 hours as required by the fire rating of construction in which they are installed. Fire dampers shall be UL 555 listed by a Nationally Recognized Testing Laboratory, and approved for each particular type of installation in accordance with UL, and the 2018 International Building Code. Provide dampers in accordance with UL requirements for the particular combinations on the project, and provide associated sheet metal construction in accordance with SMACNA guidelines. Fire dampers shall be accessible, with suitable means provided for replacing fusible links. Access doors shall be provided in ductwork, walls and ceilings. Provide dampers for grille access or 'out of wall' installation where indicated or required by the project conditions. Multiple dampers shall be joined together with mullions to form a damper of the required size where required and permitted by the UL listing, however dampers where both nominal dimensions are 36" or less shall be a single damper (no mulling of multiple dampers permitted).
2. Construction: Dampers shall be of the curtain type unless the multi-airfoil bladed type is required for the indicated size, or specified pressure or velocity ratings. Multi-bladed dampers, if provided, shall incorporate an external crank lever. Damper blades and frames shall be fabricated of galvanized steel or Type 316 or 304 stainless steel. Frames shall be one piece. Closure springs shall be stainless steel.
  - a. Stainless steel fire dampers shall be used where connected to aluminum or stainless steel ductwork.
3. Fusible Link Temperature Rating: Fusible links shall have temperature rating of 165 degrees F. unless specifically indicated otherwise.
4. Pressure and Velocity Ratings: Fire dampers dynamically rated for a duct velocity of 2,000 FPM (minimum), and pressure levels of 4-inch w.g. (minimum), or to match duct system static pressures and velocities in which they are installed, whichever is greater. Fire

dampers shall be suitable for installation in horizontal and vertical positions, as indicated on the Drawings.

5. Installation Accessories: Each fire damper shall include a sleeve and mounting angle set furnished by the damper manufacturer to ensure a UL listed installation.
6. Damper Style: Dampers shall be Type C, CR, or CO with duct transitions to match the connecting duct shape, in order to place both the damper blades and the damper frames completely out of the airstream.
  - a. Exception: Type B is acceptable where the connecting duct flow area is 4.0 sq. ft. or greater, unless indicated otherwise on the Drawings.
  - b. Exception: Type A is acceptable where a grille is installed in a fire-rated wall.
7. Sizing: Fire dampers shall have a nominal size / connection size matching the duct in which it is installed.

B. Smoke Dampers:

1. General: Provide dynamically rated smoke dampers at locations shown on the Drawings and as required to meet requirements of the 2018 International Building Code. Dampers shall be factory furnished with damper operators and the entire assembly shall be UL555S listed. Smoke dampers shall be constructed and installed in accordance with applicable requirements of the UL listing and the 2018 International Building Code. Provide dampers for grille access or 'out of wall' installation where indicated or required by the project conditions. Multiple dampers shall be mulled together where required.
2. Construction: Smoke dampers shall be parallel blade type dampers suitable for high velocity service and shall be constructed for low leakage and low pressure drop. Smoke dampers shall be furnished with a UL 555S label and NFPA 90A classified label. Damper assembly including operator shall be qualified under UL for an elevated temperature rating of 350 degrees F. The damper's UL 555S Classified leakage shall not exceed 8 CFM per sq. ft. at 4 inches w.g. (UL555S Leakage Class I). Damper frames shall be constructed of minimum 16 gauge galvanized sheet steel or Type 304 or 316 stainless steel and the blades shall be airfoil type constructed of double skins of minimum 16 gauge galvanized steel or triple-V type constructed of minimum 16 gauge Type 304 or 316 stainless steel. Damper blades shall not exceed 7 inches in width. The damper shall be UL qualified for 2,000 fpm velocity and a duct pressure of 4" w.g. Damper bearings shall be self-lubricating bronze sleeve type. Replaceable silicone rubber seals shall be installed along each blade edge in integral ribbed groove inserts in frames and blades. Compression type stainless steel seals shall be provided on top, bottom and sides of frame.
  - a. Stainless steel smoke dampers shall be used where connected to aluminum ductwork.
3. Damper Style: Dampers shall be Type C, CR, or CO to match duct shape, or equivalent, in order to place the damper frames completely out of the airstream.
4. Sizing: Smoke dampers shall have a nominal size / connection size matching the duct in which it is installed.
  - a. Exception: All rectangular ducts which are less than 16" in height, shall be provided with smoke dampers that are oversized by 2" in height. Provide duct transitions to match connecting duct size. Openings in smoke separations shall be oversized accordingly to accommodate the larger damper. Where it has been shown to be impossible to oversize the duct/opening, then a flat top and bottom frame style shall be used.

C. Combination Fire/Smoke Dampers:

1. General: Provide dynamically rated combination fire/smoke dampers at locations shown on the Drawings and as required to meet requirements of the 2018 International Building Code. Dampers shall be factory furnished with damper operators and the entire assembly shall be both UL555 and UL555S listed. Combination fire/smoke dampers shall be constructed and installed in accordance with applicable requirements of the UL listing and the 2018 International Building Code. Provide dampers for grille access or 'out of wall' installation where indicated or required by the project conditions. Multiple dampers shall be mulled together where required.
2. Combination fire/smoke damper assemblies shall be furnished with a UL 555S label and NFPA 90A classified label. Dampers shall utilize a parallel multi-blade type construction and bear either a 1-1/2 hour or 3-hour UL label, as required by the fire rating of construction in which they are installed.
3. Damper shall bear a UL 555S leakage classification rating of 8 CFM per sq. ft. at 4 inches w.g. (UL 555S Class I). Damper frames shall be constructed of minimum 16 gauge galvanized sheet steel or Type 304 or 316 stainless steel. Blade construction shall be minimum 16 gauge galvanized steel, double skin airfoil blade design or Type 304 or 316 stainless steel with a triple-V blade design. Damper shall be UL qualified for a velocity of 2,000 feet per minute and 4 inches water gauge duct pressure. Blades shall be center pivoted so they can be installed for air flow in either direction. Dampers shall be qualified under UL for an elevated temperature rating of 350 deg. F. Damper bearings shall be self-lubricating bronze sleeve type. Replaceable silicone rubber seals shall be installed along each blade edge in integral ribbed groove inserts in frames and blades. Compression type stainless steel seals shall be provided on top, bottom and sides of frame.
  - a. Stainless steel combination fire/smoke dampers shall be used where connected to aluminum ductwork.
4. Each fire/smoke damper shall be equipped with a UL classified firestat or electro-mechanical link resettable with remote or local command operation. Fusible links are not an acceptable means of heat detection. The damper shall automatically close upon detection of temperatures above 165 deg. F., or upon the detection of smoke in the ductwork.
5. Damper Style: Dampers shall be Type C, CR, or CO to match duct shape, or equivalent, in order to place the damper frames completely out of the airstream.
6. Installation Accessories: Each combination fire/smoke damper shall include a sleeve and mounting angle set furnished by the damper manufacturer to ensure a UL listed installation.
7. Sizing: Combination fire-smoke dampers shall have a nominal size / connecting size matching the duct in which it is installed.
  - a. Exception: All rectangular ducts which are less than 16" in height, shall be provided with combination fire-smoke dampers that are oversized by 2" in height. Provide duct transitions to match connecting duct size. Openings in shafts and fire/smoke separations shall be oversized accordingly to accommodate the larger damper. Where it has been shown to be impossible to oversize the duct/opening, then a flat top and bottom frame style shall be used.

D. Actuators:

1. General: Actuators for smoke dampers and combination fire/smoke dampers shall be factory furnished complete with linkages, extended shaft and damper actuators externally mounted (i.e. out of the airstream). Dampers shall be of the direct mount type. Only where direct coupling is impossible due to space constraints or geometry of damper installation shall linkages be employed. Linkages shall be designed specifically for the actuator. Actuators shall be UL 873 or UL 60730 listed.

- a. Internal mounted actuators shall be utilized in the following cases. Such cases shall be demonstrated by the Contractor to the satisfaction of the Architect / Engineer prior to utilizing an internally mounted actuator. Each internally mounted actuator proposed by the Contractor requires pre-approval by the Architect / Engineer:
  - 1) Where insufficient space exists to install and service an externally mounted actuators.
  - 2) Where the penetration is of rated exterior wall or slab and installation and service access to the actuator from the inside of the building has been demonstrated to be impractical, and no NEMA 3R or 4x actuators are available.
- 2. Construction: Actuators shall be electric (120 volt) with gear trim submerged in oil and sealed in steel or plastic case. Actuators shall be tested under UL 555S at 20,000 cycles. Actuators and the associated damper shall be suitable for elevated temperature service and shall be UL 555 and 555S listed at an elevated temperature rating of 350 degrees F. Actuators shall be suitable for continuous exposure of up to 120 deg. F. Actuator shall drive open in 15 seconds or less, and spring close in 15 seconds or less at elevated temperature. Actuators shall be UL 2043 listed for low smoke generation in ducts and plenums. Actuators shall have electronic or microcontroller-based motor control providing electronic cut off at full open so that no noise is generated while holding open, and shall have overload protection so that the actuators are incapable of burning out if stalled before reaching full rotation. The noise level of the actuator when holding the open position shall be inaudible. The actuators shall be directly coupled and employ a steel toothed cold-weld V-bolt clamp for connecting to damper shafts. Aluminum clamps or set-screw attachment are not permitted.
- 3. Control: Two position, spring return closed.
- 4. Manufacturer's Warranty: 5 years.
- E. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Greenheck, Inc.
  - 2. Ruskin Company
  - 3. Pottorff
  - 4. Cesco Products, a Div. of Mestek Inc.
  - 5. NCA; a Div. of Metal Industries Inc.
  - 6. Or equal as approved by the Professional.

## 2.3 FLEXIBLE DUCTS

- A. General: Use of flexible air ducts shall be permitted for connecting air diffusers to metal ducts. Flexible duct individual lengths shall not exceed 6 feet, or as indicated on the Drawings, whichever is less. Ducts shall be suspended with band hangers to prevent sagging and kinking, and as required by the Air Diffusion Council (ADC) Publication "Flexible Duct Performance And Installation Standards", 5th Edition. Flexible ducts shall be listed by Underwriters' Laboratories under UL 181 as a Class I flexible air duct material and shall comply with NFPA Standard 90A.
- B. Construction: Flexible ducts shall be a factory fabricated assembly consisting of a polymeric or two-ply polyester liner duct (core) bonded permanently to a coated spring steel wire helix supporting a fiberglass insulating blanket and covered with a fiberglass scrim-reinforced metalized film vapor barrier laminate. The outer vapor barrier shall have a permeance rating no greater than 0.05 perms per ASTM E96, Method A. Insulation value shall be no less than R-6. Ducts shall be suitable for no less than 140 deg. F. continuous operating temperature, 5,000 FPM



air velocity, and +6" w.g. static pressure in all sizes up to 16" flow area diameter. All materials shall be fire and smoke rated for installation within a return air plenum.

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

1. Thermaflex (Type 'M-KE' or 'M-KC').
2. Flexmaster USA, Inc. (Type '6M').
3. JP Lamborn Co. (JPL) (Type 'MHP-50')
4. Atco Rubber Products Inc. (Types '036' or '039')
5. Or equal as approved by the Professional.

## **2.4 SINGLE WALL TURNING VANES AND VANE RAILS**

- A. Turning vanes shall be installed at each mitered elbow of all square or rectangular ductwork, and shall be of sizes to suit ductwork. Vanes shall be set in factory-fabricated vane rails. Turning vanes and vane rails shall be aluminum, stainless steel, or galvanized steel, and shall match the ductwork material in which they are installed.
- B. Turning vanes shall be of the single wall (single-thickness) type, with hemmed ends on the upstream side, and lacking extended trailing ends. Turning vanes shall be factory- or shop-fabricated in accordance with Figure 4-3 and Figure 4-4 of the SMACNA "HVAC Duct Construction Standards, Metal and Flexible", 3rd edition (2005). Vane material shall be no less than 0.029-inch thick (22 gauge), and shall be suitable for no less than 2,500 feet per minute air velocity. Use SMACNA "Small" vanes (2" radius at 1.5" spacing) for all duct widths. For vanes longer than 36", install in multiple sections with the runners fastened together, or provide a tie rod secured to the vanes at mid-span.
- C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ductmate Industries, Inc.
  2. Duro Dyne Inc.
  3. C.L. Ward LLC
  4. Sheet Metal Connectors Inc.
  5. Or equal as approved by the Professional.

## **2.5 DUCT ACCESS DOORS**

- A. General Duty Duct Access Doors: Furnish and install access doors and frames to permit inspection, operation and maintenance of devices concealed behind the sheet metal work. Provide duct access doors of insulated double wall construction, not less than 24 gauge, galvanized steel. Provide doors and frames constructed of aluminum or stainless steel, in lieu of galvanized steel, where required to match the ductwork. Insulation shall be 1-1/2 PCF fiberglass, no less than 1" thick. Where ducts are uninsulated, insulation in access doors may be omitted.
1. Light Duty Doors: Systems specified for 2" w.g. and SMACNA Seal Class B or C, or lower, shall utilize a double-cam or piano hinge-and-cam, square-framed access door. Doors may be either factory-fabricated or shop-fabricated. Doors shall be fitted with foam rubber gaskets around their entire perimeter, at both the door to frame junction, and where the frame meets the duct wall. Frames shall be secured to the duct using bend-back tabs and sheet metal screws.

- a. Construct doors in accordance with Figure 7-2 of the SMACNA "HVAC Duct Construction Standards, Metal & Flexible" Third Edition (2005).
- b. Sizing: Provide duct access doors no smaller than 18" x 18". Provide ducts smaller than 20" in height with access doors two (2) inches less in height than the height of the duct. In such cases, the length of the door shall be 18".
- c. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1) Arrow United Industries
  - 2) Ductmate Industries
  - 3) Duro Dyne Inc.
  - 4) Flexmaster USA
  - 5) Pottorff
  - 6) Ruskin
  - 7) Ward Industries; a Div. of Hart and Cooley Inc.
  - 8) Or equal as approved by the Professional.

## 2.6 ACCESSORY HARDWARE

- A. Fasteners and other hardware used to fasten duct accessories that penetrate duct walls shall utilize gasket-backed sealing washers.
- B. Instrument Test Holes: Cast iron, cast zinc alloy, cast bronze, or cast aluminum to suit duct material, including cap, base flange with screw holes and adhesive-backed gasket. Size (diameter) to allow insertion of pitot tube and other testing instruments, and length to suit duct insulation thickness. The cap shall screw-on, or shall use an expansion mechanism. Coordinate quantities and locations with the Testing, Adjusting and Balancing Agent.
  - 1. Test holes on aluminum duct shall be cast aluminum.
  - 2. Test holes on stainless steel duct shall be cast bronze.
  - 3. Screw fasteners shall be galvanized on galvanized steel ducts, and stainless steel on aluminum and stainless steel ducts.
  - 4. For ducts utilizing fully welded seam and joint construction, provide welded test ports that do not use penetrating fasteners of any type. Ports shall be located on the sides or top of the duct. The test port cap shall be liquid tight. Alternatively, the TAB Agent may elect to perform airflow measuring at the duct system or exhaust hood inlets.

## 2.7 FLEXIBLE CONNECTORS

- A. General: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84 or UL723. Connectors shall be suitable for a pressure range of no less than +10 w.g. to -10 w.g.
- B. Metal-Edged Connectors: Factory fabricated with a strip of minimum 3 inches wide fabric attached using a double fold offset seam to two (2) strips of minimum 3-inch-wide, min. 24 gauge G-90 galvanized or Type 304 stainless sheet steel, or min. 22 gauge series 3003 aluminum sheet. Provide metal matching the connecting duct.
  - 1. Connectors used on round connections to fans shall have a reinforcing rib on the centerline of the fabric.

- C. Spring Links: Two brackets connected by a steel spring, and applied to prevent connector from being fully elongated or collapsed during use.
- D. Indoor System, Flexible Connector Fabric: Woven fiberglass fabric double coated with neoprene.
  - 1. Minimum Weight: 26 oz./sq. yd..
  - 2. Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
  - 3. Service Temperature: Minus 40 to plus 200 deg F.
- E. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ductmate Industries, Inc.
  - 2. Duro Dyne Inc.
  - 3. C.L Ward LLC
  - 4. Hardcast; a Div. of Carlisle Co.
  - 5. Or equal as approved by the Professional.

## 2.8 ELECTRICALLY ACTUATED REMOTE BALANCING DAMPER OPERATORS

- A. Description: Electrically actuated damper actuator designed for remote manual (i.e. non-automatic) balancing damper adjustment. The actuator shall be an electric, floating type (i.e. not spring return) shall operate on a temporary source of low voltage battery power, and shall hold the damper position against air pressure after power is removed. Plenum rated cable, up to 50 feet long, shall be extended to a power and adjustment station where a hand-held adjustment device is used to temporarily power the actuator and set the damper position. The actuator and connecting wiring shall be located and routed entirely outside of the airstream and compatible with manual balancing dampers specified elsewhere in this Section. Dampers furnished as a package with the remote operator are acceptable if they meet the balancing damper specifications found elsewhere in this Section. Radial-type dampers furnished with the remote operator and the routing of actuator wiring inside the duct airstream are not acceptable.
  - 1. Unless indicated otherwise on the Drawings, locate the power and adjustment station above the nearest accessible lay-in tile ceiling. Provide a mounting bracket and secure to the building structure, or to a wall or wall stud. Provide labeling that indicates which specific diffuser, grille, etc. is associated with the adjustment station. Labeling shall reflect the final room numbers being used by the Client Agency.
  - 2. Where no accessible ceiling is located within 50 feet of the damper, provide a recessed, maximum 3.25"-diameter round ceiling power and adjustment station or a recessed, wall mounted power and adjustment station mounted in a single gang electrical wall box.
- B. Hand-Held Adjustment Device: Furnish one (1) battery powered adjustment device to the Client Agency. The device(s) may be used by the TAB Agent during air balancing process.
- C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Greenheck - 'RBD / RBDR' series
  - 2. Metropolitan Air Technology (MAT) - 'EB-200 / 250' series
  - 3. Pottorff - 'RD-10 / 10R' series
  - 4. United Enertech - 'CD-100-ERC / RI-ERC' series
  - 5. Equal as Approved by the Professional.

## 2.9 DUCT SILENCERS

- A. General: Furnish and install rectangular, elbow and tubular type silencers of the types and sizes shown on the drawings and/or listed in the schedule on the Drawings. Silencers shall have a pressure rating no less than that specified for the connecting ductwork.

- B. Galvanized Steel Silencers with Acoustic Fill:

1. Unless specified otherwise elsewhere, outer casings of rectangular silencers shall be made of no less than 22-gauge G90 lock forming quality galvanized steel meeting ASTM A 653.
2. Outer casings of tubular silencers shall be made of G90 lock forming quality galvanized steel in the following gauges:

OUTSIDE DIA.	METAL GAUGE
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12 -36 in.	22 ga.
38-60 in.	18 ga.

3. High Transmission Loss (HTL) Casings: Outer casing shall be no less than 12 gauge galvanized steel where scheduled on the Drawings.
4. Interior partitions for rectangular silencers shall be not less than 26-gauge G90 galvanized lock forming quality perforated steel meeting ASTM A 653. Interior construction of tubular silencers shall be compatible with the respective outside casing.
5. Joints and seams shall be mastic-filled.
6. Filler material shall be inorganic glass fiber of a proper density to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin and moistureproof.
7. Fiberglass absorptive media shall be protected by poly sheeting, Tedlar®, woven fiberglass cloth, or Vibar™ encapsulation where scheduled on the Drawings. Encapsulation material shall have a flame spread index of 25 or less, and a smoke developed index of 50 or less, when tested in accordance with ASTM E 84, NFPA 255, or UL 723.
  - a. Provide 1/2" thick stand-offs between the encapsulation layer and inner sheet metal partitions of the silencer to ensure acoustical performance.
8. The silencer manufacturer shall provide a written test report demonstrating that the silencer assemblies, including the media fill, have a flame spread index not greater than 25 and a smoke developed index not greater than 50 when tested to ASTM E 84, NFPA 255, or UL 723.
9. Construction:
  - a. Units shall be constructed in accordance with the ASHRAE Guide recommendations for high pressure ductwork. Seams shall be lock formed and mastic filled. Rectangular casing seams shall be in the corners of the silencer shell to provide maximum unit strength and rigidity. Interior partitions (e.g. baffles, splitters) shall be fabricated from single piece, margin perforated sheets and shall have die-formed entrance and exit shapes so as to provide the maximum aerodynamic efficiency and minimum self-noise characteristics in the sound attenuator. Blunt noses or squared-off partitions will not be accepted.
  - b. Attachment of the interior partitions to the casing shall be by means of an interlocking track assembly. Tracks shall be solid galvanized steel and shall be welded to the outer casing. Attachment of the interior partitions to the tracks shall be such that a minimum of 4 thicknesses of metal exist at this location. The track assembly shall stiffen the exterior casing, provide a reinforced attachment detail for the interior partitions, and shall maintain a uniform airspace width along the length of the

silencer for consistent aerodynamic and acoustic performance. Interior partitions shall be additionally secured to the outer casing with welded nose clips at both ends of the sound attenuator.

- c. Interior partitions for tubular silencers shall be secured with galvanized steel radial mounting brackets welded to the partition and the outer casing. The radial brackets shall be installed full length and at 120 degree angles to each other to assure uniform spacing for consistent aerodynamic and acoustic performance.
- d. Interior partitions (i.e. splitters) in straight silencers installed less than 4 equivalent duct diameters downstream of a duct elbow duct shall be oriented so that the partition surface that runs parallel with the airflow direction is located in the plane of direction change of the upstream elbow.
- e. Sound attenuating units shall not fail structurally when subjected to a differential air pressure of 8 inches water gauge, positive or negative, from inside to outside the casing. Airtight construction shall be provided by use of a duct sealing compound on the job site material and labor furnished by the Contractor.

C. Additional Requirements for Elbow Silencers: Comply with the provisions provided above for galvanized silencers with acoustic fill, with the additional requirements also met:

- 1. All acoustical splitters (baffles) shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters shall be provided as necessary to achieve the scheduled insertion loss. All elbow silencers with a turning cross-section dimension greater than 48" shall have at least two half splitters and one full splitter.

D. Additional Requirements for Transition Silencers: Comply with the provisions provided above for galvanized silencers with acoustic fill, with the additional requirements also met:

- 1. Transitioning shall occur internal to the silencer such that the height of the gap or air passage is uniformly changing with the length of the splitters.

E. Acoustic Performance:

- 1. All silencer ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer in accordance with ASTM Specification E-477, latest revision. The test facility shall be NVLAP accredited for the ASTM E-477 or ISO 7235 test standard, latest revisions. Data from a non-accredited laboratory will not be acceptable. The test setup and procedure shall be such that all effects due to end reflection, directivity, flanking transmission, standing waves and test chamber sound absorption are eliminated.
- 2. Test data for silencers with film liner media protection shall be rated with the film and stand-offs in place.
- 3. Acoustic ratings shall include Dynamic Insertion Loss (DIL) and Self-Noise (SN) Power Levels both for "forward flow" (air and noise in same direction) and "reverse flow" (air and noise in opposite directions) with airflow of at least 2000 fpm entering face velocity. Data for rectangular and tubular type silencers shall be presented for tests conducted using silencers no smaller than the following cross-sections:

Rectangular, in. - 24 x 24, 24 x 30, or 24 x 36

Tubular, in. - 12, 24, 36, and 48

F. Aerodynamic Performance: Static pressure loss of silencers shall not exceed those listed in the silencer schedule as the airflow indicates. Airflow measurements shall be made in accordance with ASTM Specification E-477, latest revision, and applicable portions of ASME, AMCA, and ADC airflow test codes. Tests shall be reported on the identical units for which acoustic data is presented.

- G. Certification: With submittals, the manufacturer shall supply certified test data on Dynamic Insertion Loss, Self-Noise Power Levels, and Aerodynamic Performance for Reverse and Forward Flow test conditions. Test data shall be for a standard product. All rating tests shall be conducted in the same facility, shall utilize the same silencer, and shall be open to inspection upon request from the Architect/Engineer.
- H. Duct Transitions and Installation: When transitions are required to adapt silencer dimensions to connecting ductwork, they shall be furnished by the Contractor. Connect to silencers to ducts rigidly (do not use flexible connectors). Silencers shall be provided with external thermal insulation as specified for the connecting ductwork. If the connecting ductwork is provided with duct liner, provide 1" thick, 3 PCF fiberglass board insulation with a FSK vapor barrier facing on the outside of the silencer.
- I. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. BRD Noise and Vibration Control Inc.
  - 2. Kinetics Noise Control
  - 3. IAC Acoustics; a Div. of Sound Seal
  - 4. Vibro-Acoustics
  - 5. Pottorff
  - 6. Price Industries
  - 7. Ruskin
  - 8. Semco
  - 9. United McGill
  - 10. VAW Systems Ltd.
  - 11. Or equal as approved by the Professional.

## **2.10 LOUVERS**

- A. General: The .2 Contractor shall provide louvers where shown; of sizes, shapes, capacities and types indicated; constructed of materials and components as specified and as required for complete installation.
- B. Substrate Compatibility: Provide louvers with frame types (e.g. flanged, standard un-flanged, glazing frame, or stucco flange), clip angles, head and sill flashing, mounting hardware, and sill styles that are compatible with adjacent substrate and that are specifically manufactured to fit into construction openings with accurate fit and adequate support, for weatherproof installation. Refer to general construction drawings and specifications for types of substrate which will contain each type of louver.
- C. Fixed Intake and Discharge Air Louvers:
  - 1. Description: Louvers shall be the stationary drainable blade type with a frame depth of 4 inches. Frames and blades shall be .081-inch-thick 6063-T5 extruded aluminum alloy. Blades shall be located on a 37.5- to 45-degree blade angle spaced between 3.75" to 5" on-center. Jambs shall incorporate vertical downspouts. Sizes at least up to 60" wide x 120" high shall be fashioned out of a single louver, without intermediate mullions.
  - 2. Performance: Louvers shall pass air at 1000 feet per minute (FPM) free area velocity with no more than .20 inch w.g. pressure drop, for both exhaust and intake service. For intake service, the point of water penetration as defined by AMCA Publication 511 shall be no less than 1,000 FPM free area velocity. Test criteria shall be based on a 48" square sample. Louvers this size shall have a minimum 45% free area. Louvers shall bear the AMCA

Certified Ratings Seal for both Air Performance and Water Penetration, with testing performed in accordance with AMCA Publication 511.

3. Factory Finish: 70% Kynar 500® / Hylar 5000® finish shall be applied to provide 1.2 mils (30µm) factory applied, dry film thickness in accordance with AAMA 2605-02 "Voluntary Specification Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Architectural Extrusions and Panels". The color shall be custom as selected by the Architect. The finish shall have a minimum 10-year warranty against peeling, color fade, or chalking.
4. Accessories:
  - a. Birdscreens: Provided on the interior of the louver and consisting of 1/2" stainless steel or aluminum mesh with an extruded aluminum frame, with a minimum of 70% free area. Expanded metal is not acceptable. Screens shall be mounted to the frame face and be removable for cleaning. Screens may be omitted for those louver sections fitted with blank off panels.
  - b. Clip Angles: 0.125" thick aluminum, with stainless steel mounting hardware.
  - c. Head and Extended Sill Flashing: 20 gauge aluminum, with a finish matching the louver. Sill flashing shall have end dams, and overlaps on long louvers shall be sealed.
  - d. Mullion Covers (Batten Plates): 20 gauge aluminum, with a finish matching the louver.

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

1. AWV, American Warming & Ventilating (Model LE-21).
2. Greenheck Corp. (Model ESD-403 or ESD-435)
3. Louvers & Dampers, Inc. (Model IEL-4-304)
4. Ruskin (Model ELF-445DX)
5. Arrow United Industries (Model EA-415-D)
6. Airolite (Model K6744)
7. Pottorff (Model EFD-445).
8. Or equal as approved by the Professional.

## **2.11 FLEXIBLE DUCT ELBOW SUPPORT BRACES**

A. Universal-mount, 1-piece, fully adjustable, radius-forming brace to support 4-inch through 16-inch diameter flexible air ducts.

1. Classified: UL 2043.
2. Material: 100 percent recycled copolymer polypropylene.
3. Support Frame Radius: 8 inches.

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

1. Titus
2. Build Right Products LLC
3. Flexmaster USA
4. Thermoflowtech
5. Or equal as approved by the Professional.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install duct accessories according to applicable details shown in SMACNA's "HVAC Duct Construction Standards, Metal and Flexible", 3rd Edition (2005), except as elsewhere modified by the project Specifications or Drawings.
- B. Install duct accessories of materials suited to duct materials. Unless otherwise noted, use galvanized-steel or aluminum accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts , and aluminum or stainless steel accessories in aluminum ducts.
- C. Dampers shall be selected so their static pressure ratings are no less than that specified for the connecting ductwork, and the damper velocity rating is no less than the design velocity of the duct section in which each damper is installed.
- D. Install remote balancing damper operators to provide for remote balancing damper adjustment where the dampers are not easily accessible through a lay-in tile ceiling. Do not cover the damper operating assembly with any type of duct insulation. Test each operator through the complete range of adjustment prior three (3) times to concealment.
  - 1. Coordinate the locations of operators / adjustment stations with the Architect during shop drawing generation, and depict the locations on the ductwork shop drawings and/or coordination drawings. Verify operator locations with Professional prior to installation.
- E. Instrument Test Holes: Provide test holes at fan inlets and outlets, in locations as required to measure pressure drops across each item in the system (e.g. outside air louvers, filters, fans, coils, intermediate points in duct runs, etc.), and elsewhere on ductwork as indicated or required for airflow testing, measuring, and balancing. Coordinate with the Testing and Balancing Agent performing the work of Division 23 Section "Testing Adjusting and Balancing for HVAC", and provide the quantity and size of test holes where directed by the Agent.
- F. Set dampers to fully open position before testing, adjusting, and balancing.
- G. Install fire, smoke, ceiling radiation, and combination fire-smoke dampers according to the manufacturer's UL-approved written instructions. Dampers shall be selected so as to be fully compatible with the architectural assembly indicated in the architectural documents. Examine areas to receive dampers. Notify the Professional of conditions that would adversely affect installation or subsequent utilization of dampers. Do not proceed with installation until unsatisfactory conditions are corrected.
  - 1. Install fusible links in fire and ceiling radiation dampers.
  - 2. Provide access panels and doors in walls, ceilings, shafts, and ducts for inspection and service access.
  - 3. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking, bowing, or other installation error.
  - 4. Handle dampers from the frame or sleeve. Do not handle by the blades, actuator, or jackshaft.
  - 5. If any installation provision or detail on the Drawings conflicts with the damper's UL listing / installation instructions, the installation instructions shall take precedence.
- H. Turning Vanes: Provide single wall turning vanes in all mitered duct elbows, except for transfer ducts and other clean air ducts with design velocities less than 750 feet per minute, and solid



material-handling ducts (e.g. clothes dryer exhaust). Turning vanes and vane rails shall be aluminum, stainless steel, or galvanized steel, and shall match the ductwork material in which they are installed.

I. General Duty Duct Access Door Installation: Install duct access doors on sides or bottom of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment.

1. Where rectangular access doors are installed on round ducts constructed for 2" w.g. pressure class and less, provide a rectangular tap fitting to receive the rectangular door.
2. Install doors at the following locations:
  - a. Both upstream and downstream of duct coils.
  - b. Downstream of VAV terminal unit coils.
  - c. Upstream from duct filters.
  - d. At outdoor-air intake plenums. Only side mounting is permitted.
  - e. At duct drain pans for duct humidifiers. Only side mounting is permitted.
  - f. Downstream from control dampers and backdraft dampers
  - g. On discharge ductwork connected to equipment (in-line and cabinet fans, fan coil units, ducted cabinet heaters, blower coil units, water source heat pumps, ducted unit ventilators, make up air units, air handling units, etc.)
    - 1) All fans and fan-containing equipment shall have a minimum of one access door on the associated ductwork.
  - h. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links.
  - i. At each change in direction and at maximum 50-foot spacing.
  - j. Upstream from turning vanes.
  - k. Upstream of airflow measuring stations.
  - l. Upstream or downstream of other control devices requiring inspection.
  - m. Elsewhere as indicated or shown.

J. Label access doors according to Division 23 Section "Identification for HVAC."

1. Duct or plenum access doors for inspection and maintenance of fire, smoke, and combination fire/smoke dampers shall be labeled with letters not less than 1/2-inch in height that reads "FIRE/SMOKE DAMPER", "FIRE DAMPER", or "SMOKE DAMPER", as appropriate in accordance with the International Mechanical Code.

K. Flexible Duct Installation:

1. Install in accordance with Air Diffusion Council (ADC) Publication "Flexible Duct Performance And Installation Standards", 5th Edition.
2. Install flexible duct with a maximum of one 90-degree bend, with a minimum of 1 duct diameter inner bend radius using a flexible duct support brace, unless detailed otherwise on the Drawings. Use the minimum length of flexible duct to make connections. Excess length of flexible duct shall not be installed to allow for possible future relocations of diffusers. Install ducts extended to their fullest length without compression.
3. Seal insulation at both ends to maintain insulation and vapor barrier continuity.
4. Do not kink flexible ducts. Support ducts with galvanized hangers to avoid sagging.
  - a. Hanger or saddle material in contact with flexible ducts shall be of sufficient width to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger or saddle material. In no case shall the material contacting the duct be less than 1-1/2" wide.

- b. Maximum support spacing shall be 4 feet.
- 5. Flexible ducts shall not be used on return and exhaust systems. All exhaust and return system connections to grilles and registers shall be made with hard duct connections.
- 6. Exposed supply ductwork spaces shall have hard duct connections to diffusers and registers.
- 7. Flexible duct connections to diffusers are only permitted above acoustical ceilings. Do not locate flexible duct above inaccessible (drywall) ceilings. For grilles and diffusers located in drywall ceilings, provide rigid sheet metal duct connections.
- 8. Connect flexible ducts to metal ducts and diffuser necks as follows:
  - a. Apply mastic approximately 2" wide uniformly around the collar of the metal fitting / duct end / diffuser neck. Mastic shall comply with UL Standard 181B and shall be marked "181B-M" on the container.
  - b. Slide at least 2" of the flex duct core over the fitting or sleeve ends and past the bead (if present).
  - c. Secure core to collar with a galvanized or stainless steel worm gear clamp applied past the bead.
  - d. Pull jacket and insulation back over core ends. Tape jacket(s) with at least 2 wraps of tape. Tape shall comply with UL Standard 181B and shall be marked "181B-FX".
- L. Flexible Duct Elbow Support Brace Installation: All 90 degree elbows in flex ducts shall be made using flexible duct elbow support braces. Install in accordance with the manufacturer's recommendations and secure each end of the support brace to the flex duct using nylon cable ties. Do not overtighten, as to crush the flexible duct. Cut off and discard the excess from the cable tie ends. Hang the support brace from the structure above. Nylon ties shall be listed and labeled to standard UL 181B, and the fastener package shall be marked UL 181 B-C.
- M. Silencers: Install duct silencers rigidly connected to ductwork, and in accordance with the manufacturer's recommendations. The connection between duct and silencer shall be sealed as specified for the connecting ductwork.
- N. Flexible Connector Installation: Install flexible connectors to connect ducts to vibrating equipment. Transverse connections to ducts shall be made as specified in Division 23 Section "Ductwork" for ductwork transverse joints. Connector fabric shall not be overly compressed nor placed under tension when the fan is off or when operating at maximum speed and pressure. Provide spring links and/or fan thrust restraints where required. Seal fabric at the adjoining ends by applying outdoor grade duct sealant to overlapping fabric flaps a minimum 1" wide, rolling the flaps tight together, and securing the roll with stainless steel staples penetrating both layers of fabric and sealant, spaced 1" o.c. Attach flexible connectors to ductwork and equipment duct connection collars using a slip-on flange duct connector system as specified in Division 23 Section "Ductwork".
  - 1. Flexible connectors shall be omitted on ductwork connections to vibrating equipment in the following cases:
    - a. The equipment is rigidly supported or anchored, and is provided with internal flexible connector(s) and vibration isolators meeting the requirements of Division 23 Section "Vibration Controls for HVAC".
- O. Provide thrust restraints for fans as specified in Division 23 Section "Vibration Controls for HVAC".
- P. Louvers: The .2 Contractor shall furnish and install wall louvers in openings. The .1 Contractor shall furnish and install structural lintels and wall openings, The .2 Contractor shall furnish and

install clip angles, mounting hardware, flashing and frames suitable for the type of construction where louvers are installed.

1. Seal around perimeter of louver frame with elastomeric joint sealants. Use Type S, Grade NS, Class 25, Use O, neutral-curing silicone sealant of color selected by the Architect. Installations shall be completely watertight.
2. Review the architectural documents for louver overall sizes. All un-ducted and inactive portions of louvers shall be provided with double wall insulated blank off panels by the .2 Contactor, set in place with stainless steel fasteners and with edges and joints sealed with silicone caulk, or as otherwise recommended by the louver manufacturer.

### **3.2 ADJUSTING**

- A. Adjust duct accessories for proper settings.
- B. Adjust backdraft damper counter-balance devices to assist closing or opening as indicated or required.
- C. Adjust fire dampers for proper action.
- D. Final positioning of manual-volume dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

### **3.3 FIELD QUALITY CONTROL**

- A. Tests and Inspections:
  1. Operate dampers to verify full range of movement.
  2. Inspect locations of access doors and verify that purpose of access door can be performed.
  3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
  4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
  5. Operate remote balancing damper operators to verify full range of movement of operator and damper.

**END OF SECTION**