

SECTION 23 30 00 - HVAC AIR DISTRIBUTION

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Ductwork:

1. Fiberglass ductwork is not permitted.
2. Designer should evaluate cost effective means to achieve sound alleviation in the ductwork or at the air-handling unit.
3. For larger duct systems, sheet metal cost savings can be realized by specifying different Duct Pressure Classes for the portions of the system that do not experience as much static pressure due to being farther away from the fan. Indicate on drawings the points in the ductwork system where duct construction should change because of change in Duct Pressure Class. Use the SMACNA symbol for "Point of Change in Duct Construction (by the Static Pressure Class)." Be aware of possible static pressure changes in system due to abnormal or emergency conditions.
4. Ductwork used in humidification systems to be stainless steel.
5. All exhaust ductwork used in animal housing areas to be welded stainless steel.
6. All exhaust ductwork in A/BSL-3 applications to be welded stainless steel.
7. Supply air ductwork between fan and terminal boxes (medium and high): Galvanized steel, (Grade G90 or better) shop fabricated rectangular, spiral, round or oval factory fabricated.
8. Rectangular supply air ductwork from discharge or terminal box to air devices (low pressure): Galvanized sheet metal (lined where noted on drawings); factory or shop fabricated.
9. Return air ductwork: Galvanized Steel (lined where noted on drawings): factory or shop fabricated.
10. General building exhaust ductwork: Galvanized sheet metal (lined as noted on drawings); factory or shop fabricated.
11. Transfer Ducts: Internally lined galvanized sheet metal as described above for low-pressure supplies; factory or shop fabricated.
12. Sound elbows for R.A. grilles: Galvanized sheet metal (internally lined).
13. Radioisotope exhaust ductwork: 304 stainless steel all welded construction; factory or shop fabricated.
14. Laboratory ductwork: Unlined galvanized or stainless steel ductwork as required by lab service.
15. Duct sizes on drawings shall be outside sheet metal dimensions.
16. Pressure Classifications:
 - a. Low Pressure: Three pressure classifications: 1/2 inch WG positive or negative static pressure and velocities less than 2,000 fpm; 1 inch WG positive or negative static pressure and velocities less than 2,500 fpm and 2 inch WG positive or negative static pressure and velocities less than 2,500 fpm.
 - b. Medium Pressure: Three pressure classifications: 3 inch WG positive or negative static pressure and velocity less than 4,000 fpm, 4 inch WG positive static pressure and velocities greater than 2,000 fpm, 6 inch WG positive static pressure and velocities greater than 2,000 fpm.
 - c. High Pressure: Positive static pressure over 6 inches WG and less than 10 inches WG and velocities greater than 2,000 fpm.
17. Air Leakage:
 - a. Pressure testing of ductwork in the 3-inch and higher Duct Pressure Class is required..
18. Plenums:
 - a. Obtain approval from the University Project Manager for the use and arrangement of return air plenums.
 - b. Return air grilles for return air plenums shall have sound attenuation boots.

B. Duct Accessories:

1. Volume Control Dampers:

- a. Show all required locations for volume control dampers in the ductwork required for air balancing. Main ducts, branch ducts, and zone ducts must have dampers to permit proper division of air quantities. Each supply branch and outlet, and each exhaust branch must have a damper control. Parallel and opposed-blade dampers shall have 4 diameters of straight duct downstream of damper. Avoid locating dampers where it is obvious they won't be needed because of the inherent pressure drops in the system due to duct layout, longest run, etc.
 - b. Do not install a volume damper with a frame that protrudes into an airstream due to excessive noise and pressure drop.
 - c. Provide locking, indicating quadrant regulators on volume control dampers.
 - d. Dampers that are integral parts of supply or exhaust diffusers or grilles are not permitted for balancing. Provide dampers at branches or takeoffs for balancing.
 2. Take-offs:
 - a. Provide conical take-offs with a manual damper if warranted. If the main duct is not deep enough for a conical fitting, specify a 45 degree fitting with a round collar.
 - b. Do not put manual dampers in take-offs to VAV terminals.
 3. Fire and Smoke Dampers:
 - a. Provide fire and smoke dampers with a frame style that does not impinge on the duct's cross-sectional free area to decrease excessive pressure drop and noise.
 - b. Provide only "dynamic" rated fire dampers.
 - c. Where ventilation ductwork or grilles are installed in fire rated walls or partitions install fire/smoke dampers and frames such that its fire resistance shall be equal to that of the wall or ceiling in which it is located. Size dampers to provide full duct size opening through wall, partition, or ceiling.
 4. Flexible Duct:
 - a. Provide flexible duct to meet the pressure class requirements.
 - b. Provide a maximum length of 6 feet.
- C. Air Filtration and Cleaning Devices:
 1. Filter all air supplied to the building. Main building ventilation systems shall filter the air at central filter banks. Central filter banks shall have pre-filters
 2. Varicel and HEPA filters shall be accessible for either upstream or downstream servicing. Pleated panel filters shall be removable from the upstream side without disturbing the filters.
 3. Provide magnehelic gauges on all air handling unit filter banks.
 4. Exhaust air systems, which have filters for protection of heat recovery coils, shall be 4 inch MERV 7 filters. Filters shall be easily accessible and removable through side access frames.
 5. All filter doors and frames (when applicable) shall utilize closed-coil gasketing.
 6. Provide extended surface high efficiency media filters where the filtering of biological organisms is required.
 7. Provide activated carbon filters where odor control is required.
 8. Provide filters upstream of all coils.
- D. Air Terminal Devices:
 1. All air flow dampers need to be far enough away from the heating coil to ensure proper heating of the air at minimum flows.
 2. Design systems to minimize maintenance or service requirements in occupied spaces.
 3. Provide aspirating air outlets to prevent dumping of air into occupied spaces at minimal air volumes.
 4. Design system flexibility to revise zoning with minimal changes in ductwork and controls.
 5. Air terminal units to be used in a healthcare, clean room or lab facility shall have a special VAV unit liner to meet health care facility standards. No exposed fiberglass in the airstream.
 6. The use of fan powered VAV terminals is discouraged. Discuss application of fan powered terminals and other night low limit strategies with the University Project Manager.
 7. Provide manufacturer's required upstream straight distances before airflow station.
 8. Provide access panels up and downstream of reheat coils.

9. Review the Sequence of Operations for HVAC in section 23 09 93 and size coils properly for recovering from unoccupied temperatures setpoints.
- E. Building Air Inlets and Outlets:
 1. In buildings where exhaust air may be contaminated, locate the building air supply intake to avoid recirculation of the building exhaust air.
 2. Provide air intake louvers in vertical position with a face velocity and arrangement to mitigate snow intake. Provide 1/2-inch bird screen. Maximum velocity of 500 FPM face velocity.
 3. Locate air intakes as high as possible above grade. Locate bottom of air intakes minimum 20' above grade.
- F. Diffusers, Registers, Grilles:
 1. Indicate provisions for balancing airflow from outlets or into inlets on the drawings.
 2. Provide for quantities and distribution patterns as shown on the drawings.
- 1.2 SUBMITTALS
 1. Submit 1/4 inch scaled fabrication and layout drawings of metal ductwork and fittings including, but not limited to, duct sizes, locations, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between ductwork and proximate equipment. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that the area materials and rigidity are not reduced.
 2. Submit diffuser, register, and grille performance characteristics including, CFM ratings, pressure drops, NC levels, and throw patterns.
 3. Submit louver color samples for selection and approval.
 4. Submit duct access door coordination drawing for approval.
- 1.3 QUALITY ASSURANCE
 - A. SMACNA Standards:
 1. Comply with SMACNA's "HVAC Duct Construction Standards, second edition".
 2. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual".
 - B. ASHRAE Standards: Comply with ASHRAE Systems and Equipment Handbook.
 - C. NFPA Compliance: Comply with NFPA 90A "Standard for the installation of Air Conditioning and Ventilating Systems" and NFPA 90B "Standard for the Installation of Warm Air Heating and Air Conditioning Systems".
 - D. Filter media shall be ANSI/UL 900 listed, Class 1 or Class 2, as approved by local authorities.
 - E. Air terminals shall comply with ARI 880, "Industry Standard for Air Terminals" and shall bear the ARI certification seal.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
 1. Flexible Duct:
 - a. Flex-Master
 - b. Thermaflex
 - c. Hercules
 2. Balance Dampers:
 - a. Greenheck

- b. Ruskin
 - c. Pottorff
3. Fire Dampers and Combination Fire/Smoke Dampers:
 - a. Greenheck
 - b. Ruskin
 - c. Pottorff
4. Ductwork:
 - a. Hercules
 - b. Shop fabricated.
5. Filters:
 - a. American Air Filter
 - b. Farr
 - c. Koch
6. Air Terminal Units:
 - a. Price
 - b. Environmental Technologies/JCI
 - c. Titus
 - d. Nailor
7. Grilles, Registers and Diffusers:
 - a. Metalaire
 - b. Titus
 - c. Price
 - d. Nailor
8. Louvers:
 - a. Greenheck
 - b. American Warming/Air Balance
 - c. Ruskin

2.2 MATERIALS, GENERAL

A. Ductwork:

1. Galvanized Ducts: Lock-forming quality, ASTM A527, Coating designation G 90. Provide mill phosphatized finish for exposed surfaces of ducts exposed to view. Provide flat seam construction where standing seams are a hazard to the university operating personnel.
2. Aluminum Ducts: ANSI/ASTM B209; aluminum sheet, alloy 3003, Temper H14. Aluminum connectors and bar stock shall be Alloy 6061-T6 or equivalent strength.
3. Stainless Steel Ducts: ASTM A480 Type 316 with No. 4 finish on surfaces of ducts exposed to view; Type 304 with No. 1 finish for concealed ducts. Protect finished surfaces with mill applied adhesive protective paper, maintained through fabrication and installation.
4. Sealant: UL listed, Class 1, flame spread 0, fuel contributed 0, smoke developed 0, water based sealer.
5. Flexible Duct Fan Connections: Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards. UL 181 fire-resistant, neoprene coated, woven glass fiber fabric, minimum 30 oz. per square yard, crimped into metal edging strip. Suitable for 1-1/2 times duct pressure at connection. Outside flexible duct connectors shall be rated for outdoor use.
6. Flexible Duct: Comply with UL 181, Class 1.
 - a. Uninsulated: Spiral-wound galvanized steel helix, mechanically locked to fiber glass cloth fabric.
 - b. Insulated: Inner core of one ply corrugated aluminum duct, 1-inch thick, $\frac{3}{4}$ pound insulation and aluminized vapor barrier.
7. Accessories:
 - a. Turning Vanes: Multi-blade device with blades aligned in short dimension; steel or aluminum construction; with individually adjustable blades and mounting straps.
 - b. Duct Access Doors:
 - 1) Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards and as indicated.

- 2) Fabricate rigid and close fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.
- 3) Access doors smaller than twelve inches square may be secured with sash locks.
- 4) Provide two hinges and two sash locks for sizes up to 18 inches square, three hinges and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide an additional hinge for larger sizes.
- 5) Access doors with sheet metal screw fasteners are not acceptable.

B. Dampers:

1. Backdraft Dampers: Parallel blades, gravity balanced backdraft dampers shall be made of 16 gauge galvanized steel. Provide center pivoted blades of maximum six inch width, with flexible vinyl sealed edges, linked together in a rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin, and adjustment device to permit setting for varying differential static pressure.
2. Low Pressure Manual Dampers: Single or multi-blade type with position-indicating device and lock.
3. Fire Dampers: Fabricated in accordance with NFPA 90A and UL555. Fabricate curtain type dampers of galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream except for low pressure ducts up to 12 inches in height. Fabricate multiple blade fire dampers with 16 gauge galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 X 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops and lock. Fusible links, UL 33, shall separate at 160 degrees F. Provide adjustable link straps for combination fire/balancing dampers
4. Combination Fire Smoke Dampers: Fabricated in accordance with NFPA 90A, 92A, 92B, and UL Standards 555 and 555S. Dampers shall have a UL555 fire rating of
5. Each damper shall be equipped with a heat responsive device which has been tested and approved for use with the damper assembly in accordance with UL555. The heat responsive device shall have a temperature rating of 165 F or 212 F. Dampers shall be UL labeled for use in dynamic systems. The damper shall have a dynamic closure airflow rating equal to or greater than the airflow at the damper's installed location and a dynamic closure pressure rating of 4 in wg.
 - a. Dampers shall have a UL555S Leakage rating of Class II and a Temperature rating of 350 F. Dampers shall have a UL555S operational airflow rating equal to or greater than the airflow at its installed location and an operational pressure rating of 4 in wg. Damper actuators shall be factory mounted and qualified for use with the damper in accordance with UL555S. Damper actuators shall be electric type for 120, 24 volt operation or pneumatic type for 20 PSI minimum operation.
 - b. The Damper Manufacturer's submittal data shall certify all air performance pressure drop data is licensed in accordance with the AMCA Certified Ratings Program for Test Figures 5.2, 5.3 and 5.5. Damper air performance data shall be developed in accordance with the latest edition of AMCA Standard 500-D.
 - c. Damper blades shall be 16 ga galvanized steel 3 Vee type with three longitudinal grooves for reinforcement. Blades shall be completely symmetrical relative to their axle pivot point, presenting identical resistance to airflow and operation in either direction through the damper (blades that are non-symmetrical relative to their axle pivot point or utilize blade stops larger than 0.5 in are unacceptable).
 - d. Damper frames shall be galvanized steel formed into a structural hat channel shape with reinforced corners. Bearings shall be sintered bronze sleeve type rotating in extruded holes in the damper frame. Jamb seals shall be stainless steel compression type.
6. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.

C. Filters:

1. Disposable Pre-filters (MERV 8):

- a. Media: 4 inch thick, fiber blanket, factory sprayed with flameproof, non-drip, non-volatile adhesive. 20 gauge galvanized steel holding frame. Nominal size 24 inches by 24 inches. Pre-filters shall have slide-in frames, which shall be sealed to prevent bypass.
 - b. Rating: 500 FPM face velocity, 0.15 inches w.g. initial resistance, 0.5 inches w.g. final resistance.
 2. Extended Surface Retained Media Filters (MERV 11):
 - a. Media: Pleated, non-woven cotton fabric, scrim reinforced. 16 gauge galvanized steel holding frame with corrosion resistant coating. Effective media area of 50 square feet per 1000 CFM. Nominal size 24 inches by 24 inches by 12 inches deep.
 - b. Rating: ASHRAE 52; 60 percent dust spot efficiency, 96 percent average weight arrestance. 500 FPM face velocity, 0.5 inches w.g. initial resistance, 1.2 inches w.g. final resistance.
 3. Extended Surface High Efficiency Media Filters (MERV 14):
 - a. Media: Pleated, water resistant glass fiber with aluminum or kraft separators. 16 gauge galvanized steel holding frame with corrosion resistant coating. Effective media area of 50 square feet per 1000 CFM. Nominal size 24 inches by 24 inches by 12 inches deep.
 - b. Rating: ASHRAE 52; 95 percent dust spot efficiency. 500 FPM face velocity, 0.65 inches w.g. initial resistance, 1.0 inches w.g. final resistance.
 4. High Efficiency Particulate (HEPA) Filters (MERV 17+):
 - a. Media: Pleated, water-resistant glass fiber with aluminum separators; ANSI/UL 586. 16 gauge galvanized steel holding frame with corrosion resistant coating. Nominal size 24 inches by 24 inches by 12 inches deep.
 - b. Rating: 0.3 micron DOP to 99.97 percent efficiency in accordance with MI-STD-282 thermal DOP penetration test method. 250 FPM face velocity, 1.0 inches w.g. initial resistance, 3.0 inches w.g. final resistance.
 5. Activated Carbon Filters:
 - a. Assembly: Galvanized steel unit with extruded aluminum tracks to accommodate filter servicing trays in deep V arrangement for upstream/downstream side servicing with disposable panel pre-filter.
 - b. Media: Activated carbon density 34 lb./cu ft pelletized or granular to 6 by 10 Tyler mesh screen. Minimum carbon tetrachloride activity of 60 percent. Nominal size 24 inches by 24 inches by 1 inch thick. 9 pounds of carbon per 2000 CFM air flow.
 - c. Rating: 500 FPM face velocity, 0.45 inches w.g. initial resistance.
- D. Air Terminals:
 1. General: Air terminals shall not exceed sound ratings as scheduled in accordance with AMCA 301 and tested according to AMCA 300.
 2. Single-Duct Variable Air Volume:
 - a. Casing: Minimum 22 gauge galvanized steel with volume damper assembly inside. Access panel in bottom of unit for access to air valve/damper.
 - b. Insulation: Minimum 1-inch, 1.5 pound density fiberglass, neoprene or vinyl coated insulation complying with NFPA 90A and UL 181. Exposed edges of insulation coated with NFPA 90A approved sealant.
 - c. Air Valve/Damper: Extruded or cast aluminum, automatic pressure compensating. Air valve/damper to seal 100% shut off. Maximum leakage not to exceed 2 % of rated airflow at 3 inches inlet static pressure. Valve/Damper to be (normally open)(normally closed). Capable of operating with pressure drop across the unit as low as 0.4 inch w.g.
 - d. Airflow Sensor: Multi-point, averaging type.
 - e. Heating Coil: Copper tube mechanically bonded to aluminum fins. Leak tested underwater to 200 psig.
 - f. Controls: Devices compatible with temperature controls specified in Section 23 09 00.
- E. Air Inlets and Outlets:
 1. Louvers:
 - a. Test and rate performance in accordance with AMCA 500.

- b. Stationary Steel Louver: 16 gauge galvanized steel louver with 4-inch storm proof and drainable blades on 4-inch centers at 45 degree angle and channel mounted in extruded aluminum rewireable frame. frame construction with storm proof blades. Provide aluminum bird screen.
 - c. Stationary Aluminum Louver: Extruded aluminum, 0.081 inch thick louver with 4-inch storm type blades with 5-inch spacing at 45 degree angle with storm proof and drainable blades. Head, sills, and jambs to be one piece extruded structural members. Fastenings shall be either stainless steel or aluminum. Fixed blade accurately fitted and firmly secured to frames. Provide aluminum bird screen mounted in extruded aluminum rewireable frame.
- F. Grilles, Registers, and Diffusers:
 - 1. General:
 - a. Test and rate performance in accordance with ARI 880 and ASHRAE 70.
 - b. Coordinate borders and mounting frames with ceiling and wall finish.
 - c. Provide airflow capacity and throw patterns as shown. Pressure drops of diffusers and supply registers shall not exceed 0.1 inch w.g. and pressure drops for return and exhaust grilles shall not exceed 0.05 inch w.g. unless otherwise shown.
 - d. Dampers shall be opposed blade type; key or standard blade screwdriver operated from the face of the unit.
 - e. Provide opposed blade damper keys.
 - 2. Diffusers:
 - a. Louvered Face: Square, louvered face steel diffuser with movable blades accessible from face for adjustable discharge and volume damper. Border style compatible with ceiling system. Finish shall be white. Face size shall equal ceiling module size when mounted in ceiling grid; i.e., a diffuser with 24-inch x 24-inch face would be provided for a 24 x 48 ceiling grid.
 - b. Linear bar diffuser with deflection bars fixed and parallel to long dimension with opposed blade damper. Finish shall be white. Provide alignment strips to join sections together end-to-end for continuous appearance.
 - c. Slot: Aluminum linear slot diffuser with direction and volume adjustable by 180 degree controller. Number of slots shall be as shown. Finish shall be white. Diffuser shall be capable of being joined end-to-end for continuous appearance. Provide steel blankoffs, alignment pins, end caps, and borders.
 - d. Round: Round diffuser constructed of 18 gauge steel with four round cones and round inlet neck. Field adjustable airflow discharge pattern from horizontal to vertical. Finish shall be white. Provide with round steel damper and safety chain.
 - 3. Registers:
 - a. Supply Register: Double deflection, 3/4-inch blade spacing, 1-1/4-inch steel border with extruded aluminum airfoil blades and steel opposed blade damper. Front blades parallel to long dimension. Blades individually adjustable and securely held in place. Provide gasket between the frame and surface. Register finish shall be white.
 - 4. Grilles:
 - a. Perforated steel ceiling grille with 3/16-inch diameter holes on 1/4-inch staggered centers. Finish shall be white.
 - b. Wall Grilles: 45-degree deflection, 3/4-inch blade spacing, steel grille with front blades parallel to long dimension. Grille finish shall be white.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL:

- A. Accessories
 - 1. Install access doors of sufficient size at all fire damper, filter, or coil location to provide for cleaning and inspection.
 - 2. Where fire dampers are installed, paint duct red at damper.

3. Provide tight fitting access doors sealed with gaskets for inspection and replacement of fusible links. Doors shall be installed, so access is unobstructed. Where these doors occur on concealed ducts, provide access doors in walls or ceiling properly aligned to permit the servicing of the fusible links. Mark ceiling or walls according to accepted identification.

B. Ductwork:

1. Maximum flexible ductwork length shall be 6 feet. Secure flexible ductwork to collars with metal bands. Support at least every 3 feet.
2. General: Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type that will hold ducts true to shape and to prevent buckling, popping or compressing. Support vertical ducts at every floor.
3. Construct ductwork to schedule of operating pressures as shown on drawings.
4. Inserts: Install concrete inserts for support of ductwork in coordination with form work, as required to avoid delays in work.
5. Field Fabrication: Complete fabrication of work at project as necessary to match shop fabricated work and accommodate installation requirements.
6. Routing: Run ductwork in shortest route that does not obstruct useable space or lock access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of the building. Limit clearance to 1/2 inch where during is shown for enclosure or concealment of ducts, but allow for insulation thickness. Locate insulated ductwork for 1 inch clearance outside of insulation. In finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings, Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.
7. Electrical Equipment Spaces: Do not route ductwork through transformer vaults and their electrical equipment spaces and enclosures.
8. Transitions: Diverging transitions shall not exceed 15 degrees per side. Converging transitions shall not exceed 30 degrees per side.
9. Elbows: Use radius elbows with throat radius equal to duct depth wherever possible.
10. Flexible Duct Fan Connections: Install flexible duct with at least one inch slack to insure that no vibration is transmitted from fan to ductwork.
11. Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gage as the duct. Overlap opening on all four sides by at least 1-1/2 inch. Fasten to duct only.
12. Coordination: Coordinate duct installations with installation of accessories, dampers, coil frames, equipment controls and other associated work of ductwork system.
13. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at the time of the ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

C. Sealing of Ducts:

1. General:
 - a. All ducts, seams, and joints (lateral and horizontal) shall be sealed with sealant.
 - b. Metal surfaces to be joined shall be clean, dry, and grease free.
 - c. Apply a heavy brush coat of sealant to the interior metal surface of the duct slip joint, then interlock securely the duct sections and position into place.
 - d. Apply a heavy brush coat finish of sealant to the exterior metal surface duct joint or seam covering heads of lock joint screws. Ensure that all voids are completely filled to provide a continuous air pressure seal.
 - e. Where ducts are subject to excessive vibration or mechanical abuse, the exterior joint finish shall consist of a heavy coat of brush applied sealant reinforced with 2-inch wide glass fabric. Press the reinforcing fabric into the wet sealant and cover with a second coat of brush applied sealant.

2. Low pressure ducts: Seal in accordance with SMACNA standards for Class B seals.
 3. Medium and high pressure ducts: Seal in accordance with SMACNA standards for Class A seals.
- D. Fire and Smoke Dampers:
1. Install dampers with code approved sleeves.
 2. Install in accordance with UL requirements. Provide access door in duct.
- E. Grilles, Registers, and Diffuser Installation:
1. In moist areas, install grilles, registers, and diffuser with stainless steel or aluminum fasteners.
 2. When installing grilles, registers, and diffusers in existing drop ceilings provide additional T-sections as required for a finished opening for the grille, register, or diffuser.
 3. All grilles and diffusers mounted in hard ceiling, must be set in frame and be removable to limit the use of access doors
- F. Air Pressure Gauges:
1. Provide magnehelic gauges at all air handling unit filter housings.
 2. Provide an engraved nameplate on each magnehelic gauge indicating the normal operating pressure.
- G. Access Panels:
1. Install access panels for inspection, maintenance, and cleaning of all automatic dampers, fire and smoke dampers, duct turning vanes, before and after all coils, and at other locations where equipment will require service.
 2. Access panels to fire dampers shall be labeled with letters not less than 1/2-inch in height reading "Fire Damper." For locations where access panels are insulated, provide identifying labels on the exterior of the insulation.
- H. Filters:
1. Install bag-in/bag-out filters at location shown on drawings. Housing shall be labeled "Danger, Hazardous Material". Install housing in accordance with manufacturer's instructions and allow a minimum 36" clearance for access.
- 3.2 TESTING, CLEANING, AND CERTIFICATION
- A. Air Cleaning Devices: Systems shall not be operated during construction.
- B. Leakage Tests: Conduct duct leakage test in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Repair leaks and repeat tests until total leakage is less than the maximum permissible leakage as specified below.
- C. General:
1. Ductwork pressure tests shall be observed by Architect/Engineer prior to installation of insulation.
 2. Ductwork systems in the three-inch W.G. pressure class and higher shall be tested in their entirety for leaks. Arbitrary sections of ductwork in the two inch W.G. and lower pressure class shall be tested as required by the Engineer.
 3. Test Failures: Duct systems shall be repaired if test pressure and leakage requirements are not met or if air noise condition is encountered. Repairs and sealing shall be done with sheet metal, tape, sealant, or a combination thereof.
- D. Fire and Smoke Damper:
1. Dampers shall be tested and accepted in accordance with NFPA prior to project closeout.
- E. All tests shall be witnessed by the university's representative and approved by Architect/Engineer and the university representative, coordinated through the Project Manager.

END OF SECTION 23 30 00