SECTION 15891 - METAL DUCTWORK

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

Edit Note: Verify that duct pressure class is scheduled on the drawings. Pressure class is NOT called out in the specifications.

A. Extent of metal ductwork is indicated on drawings and in schedules, and by requirements of this section.

DUCT SERVICE	TYPE/CONSTRUCTION
Supply air between fan and terminal boxes (medium and high).	Galvanized steel, spiral, round or oval /rectangular.
Rectangular supply air from discharge of terminal box/fan to air devices (low pressure).	Galvanized sheet metal /spiral round and oval or rectangular (lined as noted on drawings.)
Return air ductwork.	Galvanized steel (lined where noted on drawings); factory or shop fabricated.).
General building exhaust.	Galvanized sheet metal (lined as noted on drawings); factory or shop fabricated.).
Transfer ducts.	Internally lined galvanized sheet metal as described above for low pressure supply; factory or shop fabricated.
Sound elbows for R.A. grilles	Galvanized sheet metal (internally lined). OR Fibrous glass ductboard.
Laboratory general exhaust, fume hood exhaust risers, mains and branch ducts including fume hoods.	PVC coated ductwork; factory or shop fabricated.
Outdoor air intake ductwork.	Galvanized sheet metal, rectangular, factory or shop fabricated.
Radioisotope exhaust.	316 stainless steel all welded construction; factory or shop fabricated.
Bio-hazard room air and Bio-safety cabinets exhaust air.	304 stainless steel all welded construction; factory or shop fabricated.

Dishwasher exhaust. Cagewash, tunnelwash exhaust. Autoclave	316 stainless steel all welded construction ***Edit Note: check with Owner for alternate construction.*** PVC coated with sealant, hardcast and tape. OR Aluminum with silicone sealant.
Kitchen grease exhaust.	Concealed From View: Min 16 GA, carbon steel, all welded construction. Exposed To View: Type 304 stainless steel, min. 18 GA all welded construction, with welds ground smooth for a #4 finish.
Perchloric Exhaust.	316 stainless steel with all welded construction, all welds ground smooth.
Below grade ductwork.	PVC coated.
Exterior uninsulated ductwork.	Aluminum or 304 SS or painted galvanized
Shower, locker room exhaust.	Aluminum with silicone sealant.

B. Exterior insulation of metal ductwork is specified in other Division-15 sections, and is included as work of this section.

C. Refer to other Division-15 sections for ductwork accessories.

D. Refer to other Division-15 sections for fans and air handling units.

E. Refer to other Division-15 sections for testing, adjusting, and balancing of metal ductwork systems.

1.2 DEFINITIONS:

A. Low Pressure Duct: Duct required by the drawings, specifications, or referenced standards to be constructed to 2" or less, positive or negative pressure class.

B. Medium or High Pressure Duct: Duct required by the drawings, specifications, or referenced standards to be constructed to greater than 2" positive or negative pressure class.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of metal ductwork products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with metal ductwork systems similar to that required for project.

C. References to SMACNA, ASHRAE and NFPA are minimum requirements, the Contractor shall fabricate, construct, install, seal and leak test all ductwork as described in this specification and as shown on the drawings, in addition to these minimum standard references.

D. Codes and Standards:

1. SMACNA Standards: Comply with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible" for fabrication and installation of metal ductwork. Comply with SMACNA "HVAC Air Duct Leakage Test Manual" for testing of duct systems.

2. 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".

E. SMACNA Industrial Construction Standards.

F. Field Reference Manual: Have available for reference at project field office, copy of SMACNA "HVAC Duct Construction Standards, Metal and Flexible", and SMACNA "HVAC Air Duct Leakage Test Manual".

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for ductwork materials and products. Provide product data for manufactured joining systems. Include sound attenuation by octave band for sound rated flexible duct.

* * * Edit for each project * * *

B. Shop Drawings: Submit 1/4" 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 free area, materials, and rigidity are not reduced.

C. Record Drawings: At project closeout, submit record drawings of installed systems, in accordance with requirements of Divisions 1 and 15.

D. Maintenance Data: Submit maintenance data and parts lists for metal ductwork materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with requirements of Divisions 1 and 15.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Protection: Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings. By providing end caps on all open sections, bagging small fittings, surface wrapping and shrink wrapping.

B. Storage: Store ductwork inside elevated from floor on pallets. At no time shall the inside surfaces be exposed, or stored with open ends and protect from weather.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Duct Liner:

a. CertainTeed Corp.
b. Manville Products Corp. (Schuller)
c. Owens-Corning Fiberglas Corp.
d. Pittsburgh Corning Corp.

2. Flexible Ducts:

a. Flexmaster
b. Thermaflex

3. Duct Take Off Fittings

a. Hercules Industries
b. Flexmaster
c. Thermaflex
d. Ominair

4. Round and flat oval Ductwork (low, medium, and high pressure):

a. Semco Mfg., Inc.
b. United Sheet Metal Div., United McGill Corp.
c. Sheet Metal Products Co.
d. Spiral Pipe of Texas, Inc.
e. Hercules Industries

5. PVC Coated Ducts:

a. Foremost
b. Norlock
c. Semco

2.2 DUCTWORK MATERIALS:

A. Exposed Ductwork Materials: Where ductwork is exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains, dents, discolorations, and other imperfections, including those which would impair painting.

B. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A 527, lockforming quality; with G 90 zinc coating in accordance with ASTM A 525; and mill phosphatized for exposed locations. Provide flat seam construction where standing seams are a hazard to the Owner's operation personnel.

C. Stainless Steel Sheet: Where indicated, provide stainless steel complying with ASTM A 167; Type 304 or 316; with No. 4 finish where exposed to view in occupied spaces, No. 1 finish elsewhere. Protect finished surfaces with mill-applied adhesive protective paper, maintained through fabrication and installation.

D. Aluminum Sheet: Where indicated, provide aluminum sheet complying with ASTM B 209, Alloy 3003, Temper H14.

E. Uncoated carbon steel shall comply with ASTM A569, hot rolled steel sheet.

2.3 PVC COATED DUCTWORK:

A. Steel:

1. Hot dipped galvanized steel, lock forming quality.

2. Pretreatment: Ductwork shall be cleaned and treated to accept a primer.

3. Primer: Reverse rollcoat application of primer.

4. Bake: Primer shall be oven cured.

5. Quench: Water drenched and air dried.

6. PVC: Film polyvinyl chloride (PVC) dispersion.

7. Finish: Bake.

8. Film Properties - PVC:

a. Flexibility: 180^{o}OT bend with no peeling.
b. Color: White - Olson standard.
c. Surface: Smooth, non-embossed or plenished. Free of blisters, sags, stringers, and voids.
d. Weight/Density: .035 lbs./sq. ft. @ 5 mils.
e. Hardness: 90 units A scale, Shore - Durometer, minimum.
f. Gloss: Medium.

Edit consistent with duct service table.

B. For laboratory general exhaust and fume hood exhaust inside of duct shall have 4 mil thickness with 4/1 mil exterior.

C. For below grade ductwork, exterior of duct shall have 4 mil thickness with 4/1 mil interior coat.

2.4 MISCELLANEOUS DUCTWORK MATERIALS:

A. General: Provide miscellaneous materials and products of types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

B. Fittings: Provide radius type fittings fabricated of multiple sections with maximum 15 deg. change of direction per section. Unless specifically detailed otherwise, use 45 deg. laterals and 45 deg. elbows for branch takeoff connections. Where 90 deg. branches are indicated, provide conical type tees.

C. Duct Liner: Fibrous glass, complying with Thermal Insulation Manufacturers Association (TIMA) AHC-101; of thickness indicated.

1. Unless otherwise noted, provide 1" thick, 1-1/2 lb density, fiberglass duct liner meeting ASTM C1071 Type I, NFPA 90A and 90B and TIMA (AHC-101) with minimum NRC (noise reduction coefficient) of 0.70 as tested per STM C 423 using an "A" mounting with minimum "K" factor of 0.25. Lining shall be U.L. approved, made from flame attenuated glass fiber bonded with a thermosetting resin with acrylic smooth surface treatment and factory applied edge coating. Materials shall conform to revised NFPA No. 90A Standards, with a maximum flame spread of 25 and maximum smoke development of 50.

Edit Note: Show rigid liner in plenums, casings and other areas subject to repeated entry and potential for damage. Also, use where greater than 1" liner is desired, since the rigid product resists de-lamination.

2. Provide rigid plenum liner board where indicated. Rigid liner shall be [1", 1-1/2", 2"] thick, 3 pounds per cubic foot, glass fiber bonded with thermosetting resin, with an acrylic coating, conforming to NFPA 90 and ASTM C1071.

    a. Schuller/Manville Permacote Linacoustic R-300.

D. Duct Liner Adhesive: Comply with ASTM C 916 "Specifications for Adhesives for Duct Thermal Insulation".

E. Duct Liner Fasteners: Comply with SMACNA HVAC Duct Construction Standards, Article S2.11.

F. Duct Sealant: Non-hardening, non-migrating mastic or liquid elastic sealant, type applicable for fabrication/ installation detail, as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork. All PVC coated exhaust ductwork shall be sealed with an approved chemical resistant sealant as manufactured by Foremost Co. PCD No. 8 duct sealer and wrap with hardcast tape. For outdoor ductwork, sealant shall also be U.V. resistant and weather resistant.

G. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.

1. For exposed stainless steel ductwork, provide matching stainless steel support materials.

2. For aluminum ductwork, provide aluminum support materials except where materials are electrolytically separated from ductwork.

H. Flexible Ducts: Flexible air ducts shall be listed under UL-181 standards as Class I Air Duct Material and shall comply with NFPA Standards 90A and 90B. Minimum operating pressure rating shall be 6" W.C. through a temperature range of -20^{o} to 150^{o}F; minimum working velocity rating shall be 4000 f.p.m. Contractor shall assume responsibility for supplying material approved by the authority having jurisdiction.

1. All insulated flexible ducts shall be constructed of a metalized ripstop reinforced laminate inner core, 1" thick, 3/4 lb. density fiberglass insulation with "C" factor of 0.23 or less and an outer jacket made exclusively of fire retardant reinforced aluminized material.

    a. Flexmaster Type 5M.

2. All/Where shown on drawings flexible duct shall be rated for sound attenuation. Inner core shall be black CPE supported by a galvanized steel helix, with 1" C=.23 or less insulation and metalized reinforced outer jacket. Sound attenuation shall be as scheduled below:

INSERTION LOSS, PER 10' SECTION, ZERO FLOW						
Octave Band	125	250	500	1000	2000	4000
IL (dB) 8" dia.	13	31	36	35	38	21

a. Flexmaster Type 8M

3. Non-insulated flexible ducts shall be constructed from dead soft aluminum sheet, spiral corrugated, or aluminum construction over a steel spring helix.

I. Duct Take Off Fittings to Individual Air Inlets & Outlets: Provide conical spin-in fittings at flexible or round sheet metal duct takeoffs. Where specifically shown on drawings, where the duct dimension does not allow for a conical spin-in, or at Contractor's option, provide 45° inlet rectangular to round duct take off fittings, with factory applied gasket. Fittings shall include butterfly type manual volume damper with regulator, and dual locking device. Dual locking device shall consist of two shaft mounted wing nuts, one on each sideof the damper. Wing nuts shall tighten on shafts to lock butterfly in place. Shafts shall be solid metal, rolled metal shafts are not acceptable.

Hercules Model 9000 (conical)
Hercules Model 6000 (straight-spin)

J. Underslab Ducts: For ductwork placed in concrete slabs, or under slabs on grade, fabricate PVC coated ductwork.

K. See detail on drawings for installation requirement.

L. All fasteners and hardware for stainless steel ductwork shall be made of stainless steel.

2.5 FABRICATION:

A. Fabricate ductwork in 4, 8, 10 or 12-ft lengths, unless otherwise indicated or required to complete runs. Preassemble work in shop to greatest extent possible, so as to minimize field assembly of systems. Disassemble systems only to extent necessary for shipping and handling. Match- mark sections for reassembly and coordinated installation.

B. Fabricate ductwork of gauges and reinforcement complying with SMACNA "HVAC Duct Construction Standards". Minimum 26 GA where ducts are within corridors.

C. Where the standard allows the choice of external reinforcing or internal tie rods, only the external reinforcing options shall be used.

D. If manufacturer flange joining systems are used as part of the reinforcing, the EI rating and rigidity class shall be equivalent to the reinforcing requirements of the standard. Submit manufacturer's product data.

E. Aluminum duct shall be fabricated using the aluminum thickness equivalence table in the standard. Simply increasing the thickness by two gauges is not acceptable.

F. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with center-line radius equal to 1.5 times the associated duct width; and fabricate to include turning vanes in elbows where shorter radius is necessary. Limit angular tapers to 30 deg. for contracting tapers and 20 deg. for expanding tapers. Divided flow fittings shall be 45° inlet branches, stationary splitters and elbows, or as shown on drawings.

G. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Division-15 section "Ductwork Accessories" for accessory requirements. All exhaust ductwork accessories (including dampers, turning vanes, access doors, etc.) shall be Heresite or PVC coated. All stainless steel ductwork shall have stainless steel accessories (including dampers, turning vanes, access doors, etc.) construction.

H. Fabricate ductwork with duct liner in each section of duct where indicated. Laminate liner to internal surfaces of duct in accordance with instructions by manufacturers of lining and adhesive, and fasten with mechanical fasteners. Provide sheet metal nosing on all leading edges preceded by unlined duct, at duct openings, and at fan or terminal unit connections.

2.6 LOW PRESSURE ROUND DUCTWORK:

A. Material: Galvanized sheet steel complying with ASTM A 527, lockforming quality, with ASTM A 525, G90 zinc coating, mill phosphatized. Spiral lockseam construction. Individual runouts to diffusers may be longitudinal seam.

B. Gauge: 28-gauge minimum for round and oval ducts and fittings, 4" through 24" diameter. Minimum 26 gauge where ducts are within a corridor.

C. Elbows: One piece construction for 90 deg. and 45 deg. elbows 14" and smaller. Provide multiple gore construction for larger diameters with standing seam circumferential joint. Radius to centerline shall be 1.5 times duct diameter. Spot welded and bonded construction.

Edit Note: Edit out "saddle taps" where sheet metal craftsmanship is suspect or Contractor selection is not under our control.

D. Divided Flow Fittings: 90 deg. tees, constructed with branch spot welded and bonded to duct fitting body, or saddle tap fitting, with minimum 2" flange shaped to fit main duct.

2.7 MEDIUM AND HIGH PRESSURE ROUND AND FLAT OVAL DUCTWORK:

A. General: Provide factory-fabricated duct and fittings.

B. Duct gauges given below are minimum values; in no case shall the duct gauge be less than recommended by SMACNA for the operation pressures of the systems shown on the drawings, (both positive and negative pressures), including proper re-enforcement.

C. Elbows: One piece construction for 90 deg. and 45 deg. elbows 14" and smaller. Provide multiple gore construction for larger diameters with standing seam circumferential joint. Radius to centerline shall be 1.5 times duct diameter. Fully welded construction.

Edit Note: Edit out "saddle taps" where sheet metal craftsmanship is suspect or Contractor selection is not under our control.

D. Divided Flow Fittings: Full body fittings with solid welded construction or solid welded saddle tap fittings with a minimum 2" flange shaped to fit the main duct. Provide conical laterals, conical tees, 45° inlet tees, wye fittings, or as shown on drawings. Straight tap tees shall not be used.

E. Round Ductwork: Construct of galvanized sheet steel complying with ASTM A 527 by the following methods and in minimum gauges listed.

Diameter	Minimum Gauge	Method of Manufacture
3" to 14"	26	Spiral Lockseam
15" to 26"	24	Spiral Lockseam
27" to 36"	22	Spiral Lockseam
37" to 50"	20	Spiral Lockseam
51" to 60"	18	Spiral Lockseam
Over 60"	16	Longitudinal Seam
	18	Spiral Lockseam

1. Provide locked seams for spiral duct; fusion-welded butt seam for longitudinal seam duct. Provide internal stiffener rings and external reinforcement as required to meet operating static pressures scheduled on drawings.

2. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous welds along seams.

Diameter	Minimum Gauge
3" to 14"	24
15" to 26"	22
28" to 50"	20
52" to 60"	18
Over 62"	16

F. Flat-Oval Ductwork: Construct of galvanized sheet steel complying with ASTM A 527, of spiral lockseam construction, in minimum gauges listed.

Maximum Width	Minimum Gauge
Under 25"	24
25" to 48"	22
49" to 70"	20

Over 70"	18 (or 16 GA. Longitudinal welded seam)

1. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams.

Maximum Width	Minimum Gauge
Under 37"	20
37" to 59"	18
Over 59"	16

G. Internally Insulated Duct and Fittings: Construct with outer pressure shell, 1" thick insulation layer, and perforated inner liner. Construct shell and liner of galvanized sheet steel complying with ASTM A 527, of spiral lockseam construction, use longitudinal seam for over 59", in minimum gauges listed.

Nominal Duct Diameter	Outer Shell	Inner Liner
3" to 12"	26 ga.	26 ga.
13" to 24"	24 ga.	26 ga.
25" to 34"	22 ga.	26 ga.
35" to 48"	20 ga.	26 ga.
49" to 62"	18 ga.	26 ga.
Over 62"	18 ga.	22 ga.

1. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams of outer shell.

Nominal Duct Diameter	Outer Shell	Inner Liner
3" to 34"	20 ga.	24 ga.
36" to 48"	20 ga.	22 ga.
50" to 58"	18 ga.	22 ga.
Over 58"	16 ga.	22 ga.

2. Inner Liner: Perforate with 3/32" holes for 22% open area. Provide metal spacers welded in position to maintain spacing and concentricity.

PART 3 - EXECUTION

3.1 INSPECTION:

A. General: Examine areas and conditions under which metal ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF METAL DUCTWORK:

A. Duct Sealing:

1. Seal all low pressure ducts to SMACNA Seal Class "B".

2. Seal all medium and high pressure ducts to SMACNA Seal Class "A".

B. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve air-tight and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling, popping or compressing. Support vertical ducts at every floor.

C. Construct ductwork to schedule of operating pressures as shown on drawings.

D. Inserts: Install concrete inserts for support of ductwork in coordination with formwork, as required to avoid delays in work.

E. Field Fabrication: Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.

F. Routing: Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct useable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Limit clearance to 1/2" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" clearance outside of insulation. Wherever possible 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.

G. Electrical Equipment Spaces: Do not route ductwork through transformer vaults and their electrical equipment spaces and enclosures.

H. Slope shower, locker room, and high moisture ductwork down to air device.

I. Penetrations: Where ducts pass through fire rated walls and do not contain fire or smoke dampers, protect with fire stop material installed in accordance with its listing. Where ducts pass through interior partitions or exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on all four sides by at least 1-1/2". Fasten to duct only. Where ducts penetrate non-fire rated, mechanical, electrical or acoustically sensitive walls,

provide 1/2" to 3/4" annular space between duct and wall, pack annular space with mineral wood insulation, and caulk both sides with non-hardening acoustical sealant.

J. Coordination: Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.

K. Installation: Install metal ductwork in accordance with SMACNA HVAC Duct Construction Standards and Industrial Construction Standards.

L. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of 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.

3.3 INSTALLATION OF DUCT TAKE-OFF FITTINGS:

A. Fully seal all joints.

B. Sheet metal screw regulator arm to duct after balance is complete. Mark and date position of regulator arm.

C. Insulation over regulator arm is not required.

3.4 INSTALLATION OF DUCT LINER:

A. General: Install duct liner in accordance with SMACNA HVAC Duct Construction Standards.

3.5 INSTALLATION OF FLEXIBLE DUCTS:

A. Maximum Length: For any duct run using flexible ductwork, do not exceed 5' - 0".

B. Installation: Install in accordance with Section III of SMACNA's, "HVAC Duct Construction Standards, Metal and Flexible".

3.6 GREASE EXHAUST DUCTS:

A. Install in accordance with Uniform Mechanical Code, NFPA 96, and local modifications to those codes. Connect to hoods in accordance with the hood manufacturer's listing.

B. Horizontal duct less than 75 feet in one run shall be pitched at 1/4" per foot towards the hood or a drain point. Those portions over 75 feet shall be pitched at 1" per foot.

Edit Note: Coordinate with 15250 and Architect.

C. See drawings for enclosure requirements.

1. See Section 15250 for blanket type fire rated enclosure.

2. See Division 07000 for shaft wall enclosure systems.

3. Install duct so a minimum of 3" and a maximum of 12" is maintained between duct and enclosure.

D. Use no turning vanes, tie rods, dampers or other internal structures which will collect grease. All changes in direction shall be made with radiused fittings.

E. Provide cleanouts as follows:

1. Cleanouts shall be installed in the side or top of the duct, whichever is more accessible.

2. When installed on the side, the bottom of the opening shall be a minimum of 1-1/2" above the bottom of the duct.

3. Ducts serving hoods with integral fire dampers shall have a clean out opening with 18" of the collar.

4. Horizontal ducts shall either have one opening large enough for personnel entrance or minimum 12" x 6" openings at 12' intervals.

5. Vertical ducts shall either have one opening at the top large enough for personnel entrance and descent or a minimum 12" x 6" openings at every floor.

6. Openings shall have a flanged frame, extending 1" off the duct wall. Closure panels shall be attached to the flange by means of threaded studs welded to the flange, protruding through holes in the panel and fastened by means of wing nuts. Provide "Fiber Frax" or equivalent high temperature (1500°F) rope type gasket bonded to either the gasket or panel.

7. Provide access doors in the enclosure at all cleanouts.

a. Use UL listed methods for blanket type fire rated enclosures. See Section 15250.

b. Use UL listed fire rated access doors in shaft wall enclosures. See Section 15050.

3.7 FIELD QUALITY CONTROL:

A. 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.

B. General:

1. Ductwork pressure tests shall be observed by Architect/Engineer prior to installation of insulation.

2. Ductwork systems in 3" W.G. pressure class and higher shall be tested in their entirety for leaks. Arbitrary sections of ductwork in 2" W.G. and lower pressure class shall be tested as required by Architect/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.

C. Test Equipment:

1. Portable rotary type blower or tank type vacuum cleaner with control damper. Equipment shall have sufficient capacity to properly test reasonably large duct system section.

2. Orifice assembly consisting of straightening vanes and calibrated orifice plate mounted in a straight tube with properly located pressure taps.

3. Two (2) U-tube manometers, one to measure drop across calibrated orifice and one to measure S.P. in duct being tested. Provide low differential pressure Dwyer magnehelic gauges for low leak testing in lieu of U-tube manometers.

4. Provide Dwyer magnehelic gauge with 0-.25" W.C. range for testing 0% leakage ductwork.

D. Testing Pressures and Permissible Leakage:

1. Test pressure shall be equal to the construction class. Negative pressure duct shall be tested at the equivalent positive pressure.

2. Allowable leakage shall be determined from the following equation (or figure 4-1 in the above referenced Standard):

$$F = C_L (P)^{.65}$$

Where: F = Allowable leakage factor CFM/100 Sq. Ft.
C_L = Leakage Class
P = Test pressure inches W.C.

3. Leakage class shall be as follows:

a. Seal class A, Round or oval duct, $C_L = 3$.
b. Seal class A, Rectangular duct, $C_L = 6$.
c. Seal class B, Round or oval duct, $C_L = 6$.
d. Seal class B, Rectangular duct, $C_L = 12$.
e. Seal class C, Round or oval duct, $C_L = 12$.
f. Seal class C, Rectangular duct, $C_L = 24$.

4. Record all tests using the procedure and forms in the above referenced standard.

5. All plenums and casings shall be tested by pressuring to the pressure class indicated and visually observing leakage and panel deflection.

a. No noticeable leakage shall be allowed.
b. Deflection shall be less than 1/8" per foot.

* * * Select if required * * *

6. All bio-safety room, cabinet exhaust and radioisotope exhaust shall be leak tested at [4"] S.P. at 0% leakage.

7. Kitchen exhaust shall be leak tested at [ ] S.P. at [ ]% leakage.

3.8 EQUIPMENT CONNECTIONS:

A. General: Connect metal ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery. Provide access doors where required for service, maintenance and inspection of ductwork accessories. See section 15910.

3.9 ADJUSTING AND CLEANING:

A. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances. Where ductwork is to be painted clean and prepare surface for painting.

B. Protection:

1. Store duct a minimum of 4" above ground or floor to avoid damage from weather or spills.

2. Cover all stored ducts to protect from moisture, dust or debris.

3. Maintain a cover on all ends of installed ductwork at all times, except when actually connecting additional sections of duct.

C. Ductwork contaminated or damaged above "shop" or "mill" conditions shall be cleaned, repaired or replaced to the Engineer's satisfaction.

1. Ductliner pre-installed in stored duct which has become wet may be installed if first allowed to completely dry out.

2. Ductliner in installed ductwork which has become wet must be completely removed and replaced.

3. Torn ductliner may be repaired by coating with adhesive if damage is minor and isolated. Extensively damaged liner shall be replaced back to a straight cut joint.

* * * Select as required * * *

D. For sensitive areas including but not limited to operating rooms, bone marrow transplant rooms, tissue culture rooms, ICU rooms, clean rooms, etc. Scrub all ductwork inside and out with sterilizing alcohol. Keep all ductwork capped and sealed in plastic covering at all times except during installation of that section.

E. Strip protective paper from stainless ductwork surfaces, and repair finish wherever it has been damaged.

F. Balancing: Refer to Division-15 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork; not work of this section. Seal any leaks in ductwork that become apparent in balancing process.

3.10 INSPECTION:

A. After completion of the ductwork installation, and after the Test and Balancing work, a minimum of 10% of the installed length of the supply duct system shall be inspected by an independent company specializing in such work. Inspection shall be performed using fiber optic video equipment and other appropriate techniques.

1. Sections to be inspected shall be determined by the Engineer.

B. A report, including a recording on DVD of the video shall be submitted to the engineer. The report shall document the findings of the inspection, listing any areas of concern, including evidence of water, dust, dirt and construction debris.

C. If, in the opinion of the Engineer and the Inspection company, the supply ductwork is unacceptably contaminated, the supply duct system shall be cleaned. Additional inspections shall be performed, including sections not previously inspected. This process shall be repeated until, in the opinion of the Engineer, the supply duct system is acceptably clean

END OF SECTION 15891